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Identifying areas at risk for arsenic contamination

The contamination of groundwater with arsenic poses a risk to the health of millions of people, especially in the densely populated river deltas of Southeast Asia. To date, no method has been available for identifying high-risk areas without conducting costly sampling campaigns. Now, Eawag has developed a model that allows vulnerable areas to be pinpointed using existing data on geology and soil properties. This has also enabled the researchers to detect high-risk areas in regions where groundwater studies had not previously been carried out, such as in Myanmar and on Sumatra.

Worldwide, more than 100 million people are exposed to excessive amounts of arsenic in drinking water. Arsenic is a geogenic contaminant – deriving from natural sources – which is dissolved in groundwater. In many areas, the problem is recognized, but because surface waters are polluted new wells are continually established, often without testing the pumped water for arsenic.

Making use of available data
In an article published in the journal *Nature Geoscience*, Eawag researchers have now described a method that allows high-risk areas to be identified relatively easily, without the need for expensive and time-consuming groundwater analysis. For this purpose, the team, led by geologist Lenny Winkel and environmental chemist Michael Berg, compiled existing geological data from Bangladesh, Myanmar, Thailand, Cambodia, Vietnam and Sumatra (Indonesia) to produce a uniformly classified map. The data related only to surface sediments and soil properties; surprisingly, this combination of data permits sufficiently accurate conclusions to be drawn concerning chemical and physical conditions in groundwater.

The scientists then studied the statistical relations between 30 surface parameters (geological, hydrological and climate data) and arsenic concentrations, and finally incorporated the eight most relevant variables into a logistic regression model. In particular, young river deposits with organic-rich sediments proved to be indicators of groundwater arsenic contamination. This is apparent from the maps in which the probabilities calculated for elevated arsenic concentrations are presented in a graphical form.

Supporting governments and aid agencies
Verification of the model using more than 1750 available groundwater data points from the Bengal, Mekong and Red River deltas showed that the predictions accorded well with reality. However, in areas assigned a low risk by the model, the risk cannot be assumed to be zero. “There is no such thing,” as Michael Berg points out. The environmental chemist adds that, ultimately, even a refined model, e.g. including more data from deeper rock strata, could not serve as a substitute for analysis of water samples. “But thanks to the maps, governments, local authorities or aid agencies can tell very quickly where it might be problematic to sink a well.”

New high-risk areas detected on Sumatra and in Myanmar
The latest findings from Southeast Asia are part of the Water Resource Quality (WRQ) project, an Eawag research programme studying the occurrence of geogenic contaminants in groundwater worldwide. As well as arsenic, these include fluoride, selenium and uranium. In parallel, methods are being developed to allow the populations affected to treat contaminated water, using appropriate technologies. To date, work has been carried out on a very coarse scale, but this has now been successfully refined (up to 10x10 km) thanks to the project in Southeast Asia. The new model is of

particular interest for regions where no groundwater measurement data are yet available. Accordingly, the Swiss aquatic research team applied the model to the Indonesian island of Sumatra, where an area covering 100,000 km^2 on the eastern coast was found to be at high risk for arsenic contamination. The researchers subsequently used about 100 groundwater samples to verify the probabilities predicted by the model for a region on the border between a low- and a high-risk area. Once again, the results of analyses were found to agree well with the predictions: 94% of the wells in the low-risk area showed arsenic concentrations below 10 µg/L. The maps also indicate an increased risk of elevated arsenic concentrations in groundwater in the Irrawaddy delta (Myanmar) and along the Chao Phraya river north of Bangkok (Thailand) – both areas where the risk had not previously been recognized.

Info box: Arsenic

Arsenic is one of the most important inorganic contaminants found in drinking water. This metalloid occurs as a natural component of underground rocks worldwide, with small quantities being dissolved in groundwater as a result of weathering. The inorganic salts of arsenic are tasteless and odourless, but highly toxic to humans. If ingested over long periods, even low concentrations can cause damage to health, including hyperpigmentation of the skin, disorders of liver and kidney function, and various types of cancer.

Problems arise from the fact that firstly, arsenic concentrations can vary widely at the local level and, secondly, in many areas people are completely unaware of the risk because their well water or groundwater has never been tested for arsenic. Arsenic concentrations below 10 µg/L are deemed to be safe. This concentration is therefore recommended by the World Health Organization as a guideline value for arsenic in drinking water. In the deltas of the Red River and the Mekong, Eawag detected arsenic concentrations exceeding 100 µg/L in one in five of the samples analysed, with maximum values as high as 3000 µg/L. In the Irrawaddy delta (Myanmar), a study supported by Unicef found arsenic concentrations of more than 50 µg/L at two thirds of the sampled wells.

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- Details of the Water Resource Quality project: www.wrq.eawag.ch
- The *Nature Geoscience* article “Predicting groundwater arsenic contamination in Southeast Asia from surface parameters” can be supplied to media professionals on request. For all publications, this information is embargoed until Friday, 11 July, 19:00 (CET); journalists accredited with *Nature* can also access the article directly at: http://dx.doi.org/10.1038/ngeo254
- Article on global modelling: Amini M., Abbaspour K.C., Berg M., Winkel L., Hug S.J., Höhn E., Yang H., Johnson A.C. (2008): Statistical modeling of global geogenic arsenic contamination in groundwater. Environmental Sciences and Technology 42 (1), 3669–3675.
- Photos are available at: www.eawag.ch > Media/News Archive

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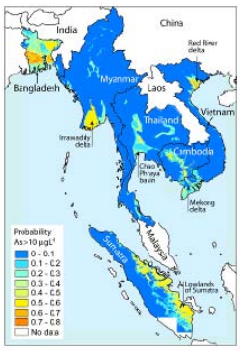
A groundwater well in Cambodia, where elevated arsenic concentrations are found at many sites along the Mekong river. Photo: Resource Development International-Cambodia

Collection of samples from a well supplying drinking water on Sumatra (Indonesia). According to the new prediction method, around 100,000 km^2 in the eastern part of the island is classified as a high-risk area for groundwater arsenic contamination. Photo: Eawag

A Cambodian showing the effects of chronic arsenic poisoning. Photo: Resource Development International-Cambodia

Sand filter for iron and arsenic removal, used by rural households in the Red River delta (Vietnam). Eawag researchers are investigating not only how such filters and their operation can be optimized, but also how their use can be effectively promoted as widely as possible. Photo: Eawag



Prediction of high-risk areas using the new model developed at Eawag. The map indicates not the expected arsenic concentrations, but the probability of levels exceeding the WHO guideline value of 10 µg/L. In certain cases, elevated concentrations may also be found at wells located in “low-risk” areas. The risk of contamination is never completely absent. Copyright: Eawag - aquatic research