Arsenic threat in Bangladesh

Mounting evidence suggests that high levels of arsenic in water used to grow crops could degrade soils, reduce yields – and find its way into food...

Little research has been done on arsenic behaviour in the flooded plant-soil systems typical of rice production

Arsenic contamination of groundwater in Bangladesh threatens the health of up to 30 million people. The problem originates in arsenic-rich bedrock of the Brahmaputra river basin that filters drinking water pumped to the surface through millions of tubewells. Levels of arsenic in drinking water are so high that WHO describes arsenic contamination of Bangladesh's water supply as "the largest poisoning of a population in history".

Now, a report from FAO suggests that arsenic in groundwater may pose an even more insidious threat. From a major review of studies conducted in Bangladesh, and elsewhere in Asia, the report concludes that people may be exposed to arsenic not only through drinking water, but indirectly though food crops irrigated by contaminated groundwater. "Where concentrations of arsenic in soil and water are high, we found a correlation with high arsenic content in crops," says Sasha Koo-Oshima, an FAO water quality and environmental officer. "Several studies have also reported a correlation between arsenic in soil and reduction in crop yields, particularly in rice. Since rice is the region's staple food, arsenic contamination could also negatively impact food security if concentrations reach levels toxic to crops."

A very toxic substance

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As
Arsenic

A member of the nitrogen family, arsenic is an odourless and tasteless semi-metal that occurs naturally in rock and soil. It can combine with other elements to form organic and inorganic arsenicals, the latter being generally more toxic and more prevalent in water. WHO says consumption over long periods of time of drinking water containing arsenic in excess of 10 micrograms per litre can lead to arsenicosis, a chronic illness that produces skin disorders, gangrene and cancer of the kidneys and bladder. More on arsenicosis from WHO...

How did the FAO review come about?

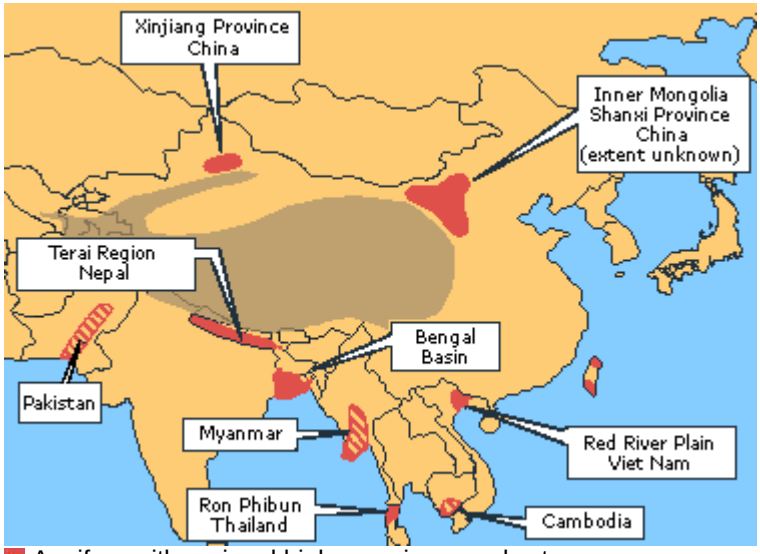
"The report builds on a study FAO undertook with UNDP funding in 2001 in Bangladesh, which is the country most affected by arsenic contamination of groundwater. That study examined how arsenic might be transferred to rice through irrigation. Up to that point, many studies had looked at the arsenic problem in Bangladesh, but only with regard to drinking water. The 2001

study produced some initial findings - for instance, evidence of arsenic accumulation in different parts of the rice plant - and was followed by studies conducted by USAID and other bilateral donors which confirmed the presence of high levels of arsenic in irrigated rice and vegetables. Later, the FAO representative in Bangladesh found resources to continue our own investigations, which led to our literature review. The significance of this report is that it provides a very detailed overview of the implications of arsenic in irrigation water for food security and food safety in Bangladesh, and in other countries of the region facing the same problem."

What are the review's major findings on irrigation as a source of arsenic contamination?

"Over the last 20 years there has been a large increase in the extraction of groundwater for irrigation in Bangladesh. Of the four million ha of land under irrigation, about 2.4 million ha are now being irrigated from shallow tubewells. In fact, approximately 95 percent of the groundwater extracted is for irrigation, mainly for *Boro* [dry season] rice production. The remaining five percent is used for domestic purposes. If we consider that a quarter of tubewells used for drinking water in Bangladesh are thought to be contaminated by arsenic, then a very high percentage of contaminated irrigation tubewells can be expected. One study we reviewed estimated that each year, the amount of arsenic added to arable soil, mainly paddy fields, through irrigation amounts to around 1,000 tonnes. In the west-southwest of Bangladesh, where the highest concentrations of arsenic are found in soil, irrigated land had higher levels compared to adjacent non-irrigated fields. From the limited data available, there are indications that soil concentrations of arsenic are increasing over time because of irrigation. But is unclear under what conditions and in what time frame this takes place, which makes it very difficult to quantify the risks."

Poisoned aquifers: A regional problem



Aquifers with regional high arsenic groundwater
Aquifers with some high arsenic groundwater sources

Since the early 1990s, arsenic contamination of groundwater has been recognized as a public health problem in Bangladesh, China and India, and more recently in Cambodia, Iran, Laos, Myanmar, Nepal, Pakistan and Viet Nam. Studies in India indicate that groundwater in a large portion of the Ganga-Meghna-Brahmaputra plain, which spans all of Bangladesh and much of India, has significant levels of arsenic contamination, placing up to 500 million people at risk. [Map: BGS/World Bank]

What do we know about the transfer of arsenic from water to crops?

"Most research on arsenic in agriculture has focused on crops that are grown under aerobic [non-flooded] soil conditions. To date, relatively little work has been done on arsenic behaviour in the flooded plant-soil systems typical of lowland production of rice, the most important staple food in Asia and the source of 70% of caloric intake in Bangladesh. From the studies we reviewed, arsenic levels in the grain of different varieties of rice in Bangladesh were as high as 1.8 parts per million, compared to levels of just 0.05 parts per million in Europe and the US. Contamination was even greater in leafy vegetables - in amaranthus and spinach, arsenic content can be double or triple the

levels found in rice. For drinking water, WHO recommends a maximum arsenic level of 0.01 parts per million, which indicates that for some people, staple food crops such as rice may be an important source of exposure to arsenic."

How much of that arsenic *is* passing into food?

"We know very little about the presence of arsenic in the food chain due to limited data. To assess the health risks of arsenic in foods we need reliable and representative data on arsenic concentrations and food consumption patterns, which are not yet robust enough for Bangladesh. Risk assessments also need to be based on inorganic arsenic - which is far more toxic than the organic form - and to date most exposure assessments have been based on total arsenic. So a reliable, quantitative risk assessment for arsenic in food cannot be made at this stage. However, we cannot exclude that known arsenic concentrations in crops, and therefore human exposure via foods, will increase over time because of the prolonged input of arsenic-contaminated irrigation water."

What can be done to reduce arsenic contamination of soil and crops?

"We are exploring several strategies that could be applied in Bangladesh and other countries facing the same problem. A major option is to optimize irrigation water use in rice cultivation. The Bangladesh Rice Research Institute estimates that farmers could apply up to 40% less irrigation water without any yield losses. Once the arsenic input is reduced, naturally present removal mechanisms may be sufficient to avoid a build up of arsenic in the topsoil. If water input can be reduced so that the soil conditions become more aerobic, the solubility of arsenic - and therefore its uptake - would be minimized as well. Another option is to promote cropping patterns that require less irrigation water - for example, and depending on the soil conditions, by replacing *Boro* rice with crops such wheat and maize, which require less water. Plant breeding should also focus on rice cultivars that are tolerant to arsenic and have a limited uptake. Rice cultivars show variation in their response to arsenic exposure but only a limited number of cultivars have been screened so far. A systematic screening is urgently needed to identify differences in arsenic uptake, tolerance and translocation."

How does FAO intend to follow up on findings of this review?

"One aim of the review is raise government awareness of the extent of the problem. To gather momentum for action of this issue, we recently presented our findings at the World Water Forum in Mexico and we're now planning an Asian regional workshop on agricultural and water quality issues, including arsenic contamination, in Shanghai in May 2007. We are also liaising with UNICEF and WHO - which are addressing the drinking water side of the problem - with the aim of developing a policy paper to guide governments in tackling arsenic contamination. One important outcome so far is that the government of Bangladesh has asked FAO for assistance in conducting a major assessment of the arsenic risk not only to crop production but in the country's livestock and fisheries sectors.

"Our review is a starting point for future work that will require funding. Much needs to be done to understand better the behaviour of arsenic in agricultural production systems, and to determine safe level of arsenic in irrigation water, soils and crops under various cropping systems. We also need to assess and quantify risks of arsenic in the food chain and to develop mitigation options and arsenic management approaches. At this point, what we do know about the arsenic risk to agriculture is troubling. But even more alarming is what we don't yet know."

- For a copy of the FAO review, "Arsenic in irrigation water in relation to food security and food safety" write to: ag21@fao.org

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