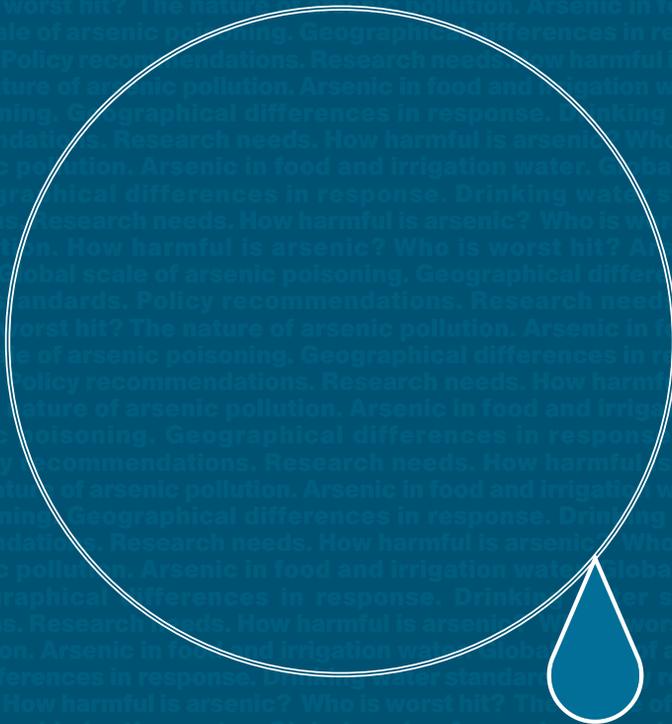


# Arsenic pollution

## A global problem

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## Key points

Naturally occurring arsenic in groundwater used for drinking, cooking and irrigation is a catastrophe of global proportions, with enormous public health implications.

130 million people across the world have been exposed to levels of arsenic in their drinking water that exceed the WHO recommended limit of 10 parts per billion (ppb); and 50 million of these – just under the population of the UK – have been exposed to levels of over 50 ppb, five times this limit [1].

The most severely arsenic affected countries are Bangladesh, India, China, USA, Myanmar, Pakistan, Mexico, Chile and Argentina. The situation may be even worse than the figures above suggest because many surveys are incomplete.

Severe current and future human impacts of arsenic poisoning are beyond doubt, and urgent action must be taken to reduce these impacts by providing access to safe water as a basic human right. Delaying mitigation will increase death and disease.

Where arsenic contaminated groundwater is used for irrigation, arsenic accumulates in the soil and is taken up by crops, especially rice. This results in increasing exposure over time; so too does the use of arsenic contaminated water for cooking and drinking.

An authoritative article in the World Health Organization (WHO) Bulletin has described the situation in Bangladesh as 'the largest poisoning of a population in history' [2].

## How harmful is arsenic?

High concentrations of arsenic in drinking water result in the highest known increases in mortality attributable to any environmental contaminant, and severe long term effects after exposure stops [3, 4].

The latest estimates suggest that 1 in 100 persons who routinely (over a lifetime) drink water containing 50 ppb or more of arsenic will die from cancers alone. For each person who dies, many more will suffer from the painful and stigmatising effects of chronic arsenic poisoning.

Ingestion of arsenic has wide-ranging health implications. Early, non-specific symptoms are followed by characteristic skin ailments including changes in skin pigmentation (melanosis) and progressively painful skin lesions (keratosis and hyperkeratosis). Increasing exposure can lead to liver and kidney disease, chronic lung disease, cardio-vascular and peripheral vascular disease, neurological effects, diabetes,



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gangrene, and multiple cancers. Lung and heart disease and lung and bladder cancers are major causes of death.

The effects of ingested arsenic are cumulative, and the symptoms have long latencies, from a few years up to a few decades, especially for cancers [4]. Consequently, some countries where tube wells have only been used for a few years have yet to see the full impact of chronic arsenic poisoning.

In Bangladesh, it has been estimated that, if unchecked, exposure to arsenic will result in a doubling of mortality from cancers [5]. Such predictions probably also apply to countries such as Nepal, Myanmar, Cambodia and Vietnam where tube well sinking occurred later.



## The nature of arsenic pollution



### Who is worst hit?

Both clinical and social impacts disproportionately affect poor people, as they tend to drink more tube well water and eat relatively more rice, especially in SE Asia. The arsenic intake in their food may equal that in drinking water, hitherto a relatively neglected contribution to overall arsenic intake. Poor people also find it more difficult to access existing safe wells or mitigation technologies.

The prevalence of arsenicosis is highest in men, probably due to their more active outdoor lifestyle, but women are also affected, particularly during and after pregnancy, and suffer more from the social impacts of arsenic pollution.

As symptoms develop, people's ability to live a normal life is reduced. They may become unable to work, severely affecting the welfare of their families.

Evidence from Bangladesh and China indicates that arsenic contributes to impaired intellectual development in children and mental illness.

### The presence of arsenic pollution

Some of the features that made arsenic such an effective poison – that it is colourless, tasteless and odourless – also contributed to the late recognition of widespread arsenic contamination of groundwater.

In the past, arsenic testing was not routine. But in a variety of geological settings, arsenic is naturally present in groundwater that is easily accessible and otherwise used by humans.

Until the early 1980s, arsenic in drinking water was only recognised as a serious problem in three countries: Argentina, Chile and Taiwan. Awareness of the scale of the problem increased during the 1980s and, following its recognition in Bangladesh in

the late 1980s, developed into an international environmental issue.

Natural arsenic contamination in groundwater occurs in diverse geological conditions; in unconsolidated sediments and in sedimentary, igneous and metamorphic rocks with a huge range of ages. However, most of the worst cases are found in the tropical river basins of Asia, especially in deposits of rivers draining young mountain ranges, where sandy aquifers are interbedded with silts and peats.

Arsenic pollution is found in climates ranging from the hot and humid tropics, to arctic Alaska and hyperarid deserts. Despite this diversity, in any given location, arsenic contamination usually has a well-defined relationship to particular geological units and hence to particular depths of wells.

### Arsenic in food and irrigation water

Where arsenic-rich groundwater is used for irrigation, the arsenic concentration in the soil gradually builds up, and inevitably leads to more arsenic being taken up by plants. Paddy rice is the crop most affected, because arsenic is most readily available

to plant roots under wet soil conditions under which this crop is grown.

The effect of arsenic in food and water is thus both additive and cumulative. Studies from West Bengal, Mexico and Chile underline the need to consider the combined effects of exposure from food and water.

The worst conditions occur in some subsistence rice communities of Asia, where wetland rice (paddy) is irrigated with arsenic-contaminated water. The staple diet of agricultural labourers and their families typically comprises locally-grown rice often with little fruit, vegetables or meat. The deficiency of vitamins, minerals and protein reduces the ability to resist the toxic effects of arsenic.

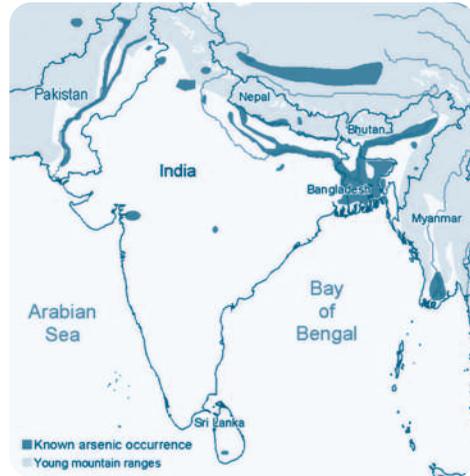
In such settings, with their food cooked in, and washed down with, contaminated well water, the daily intake of arsenic can be ten times the recommended maximum. Thus, poverty and environmental hazards interact to exacerbate the sufferings of poor, rural populations.

## Global scale of arsenic pollution

Arsenic is a global problem. At least 130 million people across the globe have been, or are exposed to, levels of arsenic in their drinking water exceeding the WHO limit of 10 ppb.

The geological, geomorphological and geochemical reasons for high levels of arsenic in groundwater are varied, and require different mitigation policies and practices. The health effects also vary. For example, the USA has many diverse examples of natural arsenic contamination in groundwater, but few cases of poisoning because of better health and diet.

Asia is the most arsenic-affected continent, owing to a combination of exposure and poverty. Almost 90% of those known to have had high exposures (>50 ppb) in drinking water live in Asia. The greatest concentration of suffering occurs in a band of alluvial basins – the Indus, Ganges, Brahmaputra, Irrawaddy, Mekong and Red rivers –



where similar reasons for contamination exist and consequences are most severe. In some areas in this region, it is tragic that chronic arsenic poisoning began after a deliberate policy to exploit shallow groundwater was initiated in the 1970s to combat enteric diseases caused by drinking polluted surface water.

## Geographical differences in response

There appear to be geographical differences in health effects of arsenic exposure; various conditions seem to have different thresholds in the USA and some Asian countries. It is not currently known how these differences reflect poverty, diet, lifestyle and the ability to afford mitigation technologies. However, measures to reduce poverty will also reduce the disease burden of arsenicosis.

Some uncertainty stems from differences in the quality and quantity of information between countries. Geochemical differences in the waters may also be significant in establishing how far latency differs between areas.

## Drinking water standards

A major policy issue is the specification of drinking water standards. Between 1996 and 2006, most economically advanced countries lowered their standards from 50 ppb to 10 ppb of arsenic in line with WHO guidance. However, less economically advanced countries, especially most of the severely arsenic-affected countries, have not revised their standards.

Objections to lowering the standard come from fears of unaffordable expense, failing to prioritise mitigation, and uncertainty about clinical effects at low-level exposure. However, there is increasing evidence of illness at concentrations of <50 ppb in drinking water [6], especially in countries where exposure from food (rice) is also high.

Objectives should therefore not be confused with means, and the 10 ppb WHO guideline should be adopted in all affected countries, implemented in a phased manner within a realistic timescale.



## Policy recommendations

Policy recommendations for mitigating and preventing arsenic pollution in food and water globally are:

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- 1. Survey at-risk areas.** In suspect areas that have not yet been tested, there is an urgent need to carry out reconnaissance surveys to determine the location, scale and causes of contamination. Normally, this will be followed by 'blanket' testing of all wells in affected areas, and surveys of irrigation wells to assess the risks to agriculture and human health.
  - 2. Develop awareness** at all levels of society, of the potential dangers of arsenic in food and water. Governments should develop arsenic information and communication strategies that operate across sectors and at multiple levels from national to household level, and include farmers and those responsible for water resource and agriculture policy.
  - 3. Assess the availability** of low-arsenic water sources for human consumption, and enable access to them in high risk areas.
  - 4. Strengthen the capacity of agricultural research institutions** to develop and test crops, alternative cropping systems, water management processes, and soil rehabilitation methods; and to breed rice for low arsenic uptake into the grain.
  - 5. Help farmers to adapt** by maximising rain-fed production, where alternative water sources for irrigation are insufficient.
  - 6. Prioritise water-supply and treatment interventions** in the worst affected areas (e.g. the >2000 villages in Bangladesh where every well is contaminated), and educate the affected people about arsenic poisoning and practical mitigation technologies for each area.
  - 7. Establish local and affordable capability** to test water supplies where arsenic surveys have been completed. Organisations must be equipped to coordinate and monitor arsenic mitigation according to time-bound plans to eliminate arsenic exposure.

**8. Strengthen the institutional capacity** to understand, plan, implement, support and monitor arsenic mitigation. Measures should include formal training in schools and universities, and of farmers.

**9. Allocate more funds to arsenic mitigation,** following a plan that is proportional to the degree of human suffering and maintenance of the natural resource base in each affected country, supported by international donors and NGOs where necessary. Recognise that reducing poverty will reduce the impact of arsenic.

**10. Adopt the WHO guideline** in all affected countries and implement in a realistic time scale.

### Research needs

**11. Identify alternative safe water sources, and assess their sustainability.** This applies especially to pumping from deeper alluvial aquifers in coastal areas where safe aquifers are overlain by contaminated ones.

**12. Assess further the contribution of food** to arsenic exposure, and quantify the combined impact of contaminated food and water on human health.

**13. Investigate the impact of arsenic on irrigated agriculture,** and introduce mitigation measures to reduce accumulation of arsenic in irrigated crops, including: breeding arsenic-tolerant rice, crop substitution, and measures to immobilise arsenic. For the poorest and most malnourished societies, action-research should be conducted to reduce suffering by intervening in dietary and culinary practices.

**14. Assess the likely impact of climate change** on the increased demand for, and reduced availability of, groundwater, and its feedback by way of exposure to arsenic. Climate change adaptation programmes might be used to explore ways to adapt food production techniques such as changing to different types of rice and vegetables, and/or changing water management and food preparation practices.

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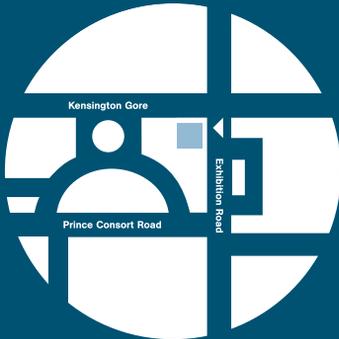
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