Environment

Water & Environmental Sanitation Network (WES-Net India)

Solution Exchange for WES-Net India
Consolidated Reply

Query: Arsenic levels and Drinking Water Quality / from A.N. College, Patna / Advice

Compiled by Preeti Soni, Resource Person and Moderator; additional research provided by Ramya Gopalan, Research Associate
8 September 2005

Original Query: Nupur Bose, Department of Environment and Water Management, A. N. College, Patna

Posted: 22 August 2005

I am working in an academic department that deals with water resource based issues. So far, our research work has involved wetland studies, industrial waste water treatment, and ground water contaminants like arsenic and fluoride. Currently, my research group has been doing some pioneering work in the assessment of arsenic contamination in ground water in a few districts in Bihar. Very high arsenic contamination has been recorded in densely populated rural areas, which demands immediate mitigation measures. Stakeholders are already looking into mitigation techniques. Bihar is a very poor state with negligible infrastructure and health services that are still inaccessible to most of the contaminated areas.

W.H.O. has set the 10 ppb. level as the permissible limit of arsenic content in drinking water, Australia has 7 ppb. mark with USA set to lower its acceptable limits from its current permissible limit. Arsenic is a bio-accumulative toxin, and epidemiological studies have revealed that that continuous intake of As. contaminated water show symptoms at a later stage, resulting in reduced life span and fatalities.

My query is -
Is it justified to declare Arsenic contaminated water sources of less than 50 ppb. as safe for mitigation purposes, particularly among the rural poor in India? What will be the implications of regarding below 50 ppb as "SAFE"?

Your response will be vital in shaping my stance and I look forward to receiving it.

Solution Exchange received responses from:

1. **Paul Deverill, UNICEF India, New Delhi**
2. **D Chandrasekharam, Indian Institute of Technology (IIT), Mumbai**
3. **A K SenGupta, Department of Civil & Environmental Engineering, Lehigh University, Pennsylvania ***
4. **A K Paikaray, Mahavir Yuvak Sangh, Bhubaneswar**
5. **D K Raut, Department of Epidemiology, All India Institute of Hygiene &**

Public Health, Kolkata

6. **D Chakraborti, School of Environmental Studies, Jadavpur University, Kolkata**
7. **Ruchita Khurana, Toxics Link, New Delhi**

* Offline contribution

Further contributions are welcome!

Summary of Responses

Arsenic contamination and the associated health impacts is a major problem in many countries. Inorganic arsenic is found mainly in natural water sources, and organic arsenic in seafood. The main sources of arsenic contamination in drinking water are both natural (resulting from water flowing over arsenic rich rocks) and human induced (due to industrial effluents and combustion of fossil fuels). The affects include chronic poisoning which causes cancer of the skin, lungs, urinary bladder and kidney and other skin changes such as pigmentation changes and thickening. Other health effects that may arise from arsenic exposure are hypertensive and cardio vascular disease, diabetes and reproductive effects.

While there is a concern regarding the arsenic levels in drinking water, regulating arsenic concentrations has been a controversial issue. Different agencies, such as the World Health Organization (WHO) and US Environmental Protection Agency (EPA) base their standards on specific factors including (a) water intake, (b) nutritional sources and (c) dietary sources. As these factors vary across countries and regions and are dependent on the socio-economic contexts, setting of uniform standards becomes complicated. This issue is highlighted in the present query, which revolves around setting the standards specifically for India at **50 ppb** (parts per billion) as an interim value by the **Department of Drinking Water Supply,** or at **10 ppb** as recommended by the **WHO** and the **Bureau of Indian Standards** (BIS). The query raises not only a technical issue pertaining to standards but also a very relevant social concern regarding safe drinking water. Based on the responses received and desk review of literature, a summary is provided below.

Arguments in favour of setting the **standard at 10 ppb** include:

- **Susceptibility**: The foremost reason pertains to impact of arsenic on **human health**. A standard specifying a lower arsenic contamination value may be favourable in light of high susceptibility of the populations in many parts of India due to:
  - ***Higher water intake***: Daily water intake of people in the arsenic affected areas in tropical countries in India and Bangladesh is high. Contamination levels are usually undermined as the intake of arsenic is considered only through drinking water, whereas it is also through water used for cooking and agricultural irrigation. It is reported that arsenic has entered the food chain with rice roots having a high arsenic content.
  - ***Malnutrition*:** It is observed that malnutrition, which is one of major challenges faced by health agencies and social groups in India, tends to aggravate the risks of arsenic effects.
  - ***Genetic make up and dietary habits:*** Differences in metabolism of arsenic in infants, children and adults could be responsible for the differing susceptibilities between the sub-populations. Differences in dietary habits as well as lifestyles (like smoking) have an impact as well. The implication of variation to susceptibility implies that lower levels of arsenic are more desirable than would be the case if the risks were more uniform.
- **Equity**: The WHO-recommended guideline is accepted in almost all developed countries. Setting a higher value would imply **disparity** and leads to **dissatisfaction** in a democratic society such as India. In terms of equity and ethical context, the health impacts and implications of setting a lower value may be considered the same for all.

Arguments in favour of setting the **standard at 50 ppb** include:

- **Scientific uncertainty**: Lack of a universal definition of diseases caused by arsenic, and discrepancies in the arsenic related symptoms between individuals, population groups and geographic areas, complicates the assessment of its burden on health (especially for cancer). For example, in USA even with arsenic standard of 50 ppb there have been no validated cases of hyperkeratosis or cancer due to arsenic. On the other hand, it is also reported that people in villages across different countries have benefited after reduction of arsenic from high concentrations to less than 50 ppb.
- **Monitoring implications:** Analytical quality control and external validation for arsenic is difficult. Accurate measurement requires laboratory analysis using complex and expensive techniques. Field test kits can detect high levels of arsenic content but are not reliable at lower concentration levels. The reliable way of testing to 10 ppb relies on sophisticated equipment – the Atomic Absorption Spectrophotometer (it was mentioned that there may only be two of these available in Bihar, which are not used for arsenic testing). Given the vast numbers of private and public tube wells that need to be tested, other techniques can be used such as spectrophotometry and field test kits, using an interim value of 50 ppb. Testing should lead to mitigation; in many cases the immediate response can be to switch sources to a less contaminated supply.
- **Financial implications**: A major difference between 10 and 50 ppb limit lies in terms of removal strategies and their financial implications, including the burden to the government in terms of monitoring and enforcement.
- **Implications concerning removal technologies**: Removal of arsenic to a level of 50 ppb is easier than to a lower concentration (though both have associated constraints). The availability of adequate arsenic removal technologies is also a concern. For instance, arsenic removal plants installed in different parts of West Bengal have reported arsenic removal to 50 ppb and not 10 ppb.

Setting a standard with a lower limit for arsenic contamination in drinking water would be desirable given its adverse affects on the human population. However, setting a standard is not an end in itself, and a lot depends on its effective enforcement and implementation strategies. The constraints in this regard need to be understood and attempts made to overcome them. Some recommendations from the members are:

- Work to **improve water quality across the board**. This is a much greater challenge, for which arsenic testing and mitigation could be an effective entry point.
- Facilitate on-going **community education and awareness.**
- Improve the **state's capacity to use adequate techniques** to measure down to 10 ppb.
- Promote the **adoption of surface/canal irrigation for farming** and allow the groundwater to be used for drinking. This would facilitate groundwater to regain its normal flow pattern, and over a period of time reduce arsenic content at least in certain aquifers.
- Encourage **rain water harvesting** and use of surface water after necessary purification which is comparatively arsenic free.

Related Resources

Recommended Organizations

West Bengal and Bangladesh Arsenic Crisis Information Centre *(from Ramya Gopalan, Research Associate)*
http://bicn.com/acic/

Online focal point for environmental health disasters arising as a consequence of arsenic contamination in drinking water - information bank

Recommended Contacts

Prof. S Khuntia, Regional Research Lab, CSIR - Council of Scientific and Industrial Research, Bhubaneswar *(from A K Paikaray, Mahavir Yuvak Singh, Bhubansewar)*

Recommended as a source for information on assessing health impacts of arsenic contamination in Orissa

Recommended Websites

CD on "Present and Future Danger of Arsenic Contamination in Ganga - Meghna - Brahmaputra (GMB) Plain" *(from D.Chakraborti,* School of Environmental Studies, Jadavpur University, Kolkata)

Contains an audiovisual representation summarizing collaborative research studies on arsenic contamination done by School of Environmental Studies

Drinking Water Specification *(from D.Chandrasekharam, Indian Institute of Technology, Mumbai)*
Bureau of Indian Standards 2003: ISO 10500: 1991 Edition 2.2 (First revision incorporating Amendments 1 and 2) dated September 2003

The standard has set the desirable limit of arsenic concentration in drinking water to be 10 microgram per litre.

Impact of irrigation wih As-rich groundwater on soil and crops: a geochemical case study in Maldah District, West Bengal *(from D.Chandrasekharam. Indian Institute of Technology, Mumbai)*
Norra, S., Berner, Z., Aggarwala, P., Wagner, F., Chandrasekharam, D., Stüben, D. (2005). Applied Geochemistry (in press).

The paper deals with the impact of use of arsenic contaminated groundwater for irrigation

Natural Arsenic in Groundwater*(from D.Chandrasekharam, Indian Institute of Technology, Mumbai)*
Edited by Jochen Bundschuh, Prosun Bhattacharya and D Chandrasekharam. Published by A.A. Balkema Publishers, London.

The book deals with arsenic problem in groundwater and suggests viable solution to mitigate it

Ground water and drinking water *(from Preeti Soni)*
http://www.epa.gov/safewater/arsenic.html

Provides an overview of the Safe Drinking Water Act that required EPA to revise its 50 ppb standard for arsenic in drinking water to a 10 ppb standard

Arsenic in drinking water *(from Preeti Soni)*
http://www.who.int/mediacentre/factsheets/fs210/en/

This WHO site provides fact sheet and information on arsenic in drinking water

Recommended Documentation

Nutritional Factors and Susceptibility to Arsenic - Caused Skin Lesions in West Bengal, India *(from Ruchita Khurana, Toxics Link, New Delhi)*
Mitra S.R et al (2004). Environmental Health Perspectives 112 (10): 1104 - 1109
http://www.solutionexchange-un.net.in/environment/cr/res05090504.pdf (size: 172 KB)

This article highlights the link between malnutrition and risk of skin lesions due to arsenic contamination

Recommended by Dipankar Chakraborti, School of Environmental Studies, Jadavapur University, Kolkata

Painful As Incident
http://www.solutionexchange-un.net.in/environment/cr/res05090501.pdf (size: 88 KB)

The Article relates a painful arsenic incident in West Bengal, India

Million Dollar Arsenic Projects in Bangladesh: Arsenic Situation Deteriorated in Eruani Village of Laksham P.S., Comilla District from 1997-2005
http://www.solutionexchange-un.net.in/environment/cr/res05090502.pdf (size: 723 KB)

The study enumerates the level of exposure to arsenic and the consequential impacts particularly for children, and highlight the need for education and awareness among villagers

Arsenic drinking water regulations in developing countries with extensive exposure
Smith A.H and Smith M.M.H (2004). Toxicology 198: 39-44
http://ist-socrates.berkeley.edu/~asrg/04SmithAsDWRegulations.pdf (size: 205 KB)

This article argues that developing countries with large populations exposed to arsenic in water might reasonably be advised to keep their arsenic drinking water standards at 50 mg/l

Are some animals more equal than others?
Mukherjee, A et al (2005). Toxicology 208: 165-169
http://www.solutionexchange-un.net.in/environment/cr/res05090503.pdf (size: 129KB)

This article establishes the link between exposure to arsenic and the limits stipulated for arsenic containment

Further documentation identified by Ramya Gopalan, Research Associate

Providing Arsenic-Free Water in Remote Villages in West Bengal, India, Mondialogo
http://www2.mondialogo.org/engineering-award/winners/water-india/?&L=en (size: 17 KB, 711 KB)

Management summary and project presentation of Providing Arsenic-Free Water in Remote Villages in West Bengal, India

A dugwell program to provide arsenic-safe water in West Bengal, India: preliminary results
Smith M.M et al (2003). Journal of Environmental Science and Health, Jan; 38(1): 289-99.
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&list_uids=12635833&dopt=Abstract (Abstract)

This study presents the preliminary results of implementing a dug well program to provide arsenic safe water in some villages of North 24 Parganas in West Bengal, India

Arsenic Crisis in Indian Subcontinent: An Indigenous Solution
Arup K. SenGupta, Department of Civil and Environmental Engineering, Lehigh University
http://www.lehigh.edu/~aks0/arsenic.html

Provides features, costing and technique of wellheads as a mechanism to provide arsenic safe water

Drinking Death in Groundwater: Arsenic Contamination as a Threat to Water Security. Part Four, ACDIS, 2004
http://www.acdis.uiuc.edu/Research/OPs/Moinuddin/contents/part4.html

Research paper detailing arsenic contamination around the world - origin, range of contamination and number of people exposed

Proposed Revision to Arsenic Drinking Water Standard, USA, EPA, 2000
http://www.epa.gov/safewater/ars/arsenic.pdf 755KB

Proposed rules for the revision of the arsenic rule in the USA

Arsenic in Drinking Water, University of Nevada
http://www.unce.unr.edu/publications/FS01/FS0108.pdf (size: 159 KB)

Paper providing the issues related with revising the arsenic standard in the context of the United States and also tables the available techniques that facilitate arsenic removal.

Solution Exchange Responses in Full

Paul Deverill, UNICEF India, New Delhi

Good question. Here is another. What is the meaning of safe?

WHO's guideline value for As, at 10 ppb, is in fact provisional. It would be a great deal less (<1 ppb), but the origination have set the guidelines reflecting global capacities to test reliably down to that level. In fact, the only reliable way of testing down to 10ppb is using an Atomic Absorption Spectrophotometer - a sophisticated piece of lab equipment. In Bihar, I believe there are two such machines. As far as I know, neither is set up to measure arsenic...maybe someone else can comment here.

Given the vast numbers of tube wells, private and public, in Bihar, especially along the Ganga, that need to be tested, other techniques such as spectrophotometry and the most reliable field test kits can be used, using an interim value of 50 ppb (set by the Department of Drinking Water Supply). Testing should lead directly to mitigation; in many cases the immediate response is to switch sources to a less contaminated supply. This will save people's lives.

However, its very important that such tests are verified using calibrated AAS from an accredited testing institution - something that must be written into any testing protocol. Meanwhile, the state's capacity to use AAS to measure down to 10 ppb must be improved.

The arsenic problem must still be seen in perspective. Tens of thousands of children under five die in Bihar every year of diarrhoeal disease, with faecally contaminated water being a major factor. Whilst we deal with the Arsenic menace, we have to do more to improve water quality across the board. That is a much greater challenge, for which arsenic testing and mitigation may be the entry point.

D Chandrasekharam, IIT, Mumbai

My posting is particularly with reference to West Bengal. Arsenic pollution in this state has reached a state that there is no point at this point of time discussing about arsenic limit in drinking water in West Bengal. The immediate action is to provide arsenic free drinking water to the millions affected by arsenic related diseases in this State and particularly save children affected by this calamity.

My recent research in collaboration with Germany states that arsenic has entered the food chain with rice roots having arsenic content as high as 169 ppm (Norra et al, 2005, Applied Geochemistry in press..this can be viewed from Elsevier web site). This has lot of implications since it is related to the irrigation practice followed in West Bengal (it is true in all irrigated land in India). I have suggested a viable solution to mitigate this problem in a book edited jointly by Jochen Bundschuh, Prosun Bhattacharya and D Chandrasekharam titled "Natural Arsenic in Groundwater, published by A.A. Balkema Publishers, London). On a long term basis, it is advisable for the farmers to adopt surface/canal irrigation and leave the groundwater only for drinking. This will allow the groundwater flow regime to regain its normal flow pattern and over a period of time it is possible to get water with low arsenic content in certain aquifers in a multi aquifer system like Bengal basin.

A K SenGupta, Department of Civil & Environmental Engineering, Lehigh University, USA

As of today, the maximum contaminant level (MCL) of arsenic in USA for drinking water is 50 ppb and to my knowledge, not a single person here has been diagnosed with cancer or a major symptom of hyperkeratosis. If people in Indian subcontinent were drinking water with less than 50 ppb of arsenic, we won't be knowing

or talking about the arsenic crisis in that region today. At the same time, I fully understand that it is a politically sensitive issue because the MCL will be reduced to 10 ppb here with effect from next year and WHO recommends 10 ppb. Such a disparity in a democratic society raises debates and dissatisfaction. Again from a cost-benefit viewpoint, reducing the MCL to a value below 50 ppb does not offer any significant advantage because other environmental factors (e.g., air quality, water contamination by pathogens) pose predominant threat, thus defeating/neutralizing the benefit of lower As level. I personally would like to see changes in phases. For example, the arsenic MCL may be reduced to 20 ppb after three years. And, then another round of change. I know from my personal experience that people in remote villages have greatly benefited following reduction of arsenic level from very high concentrations to less than 50 ppb. Finally, MCL does not mean anything unless it is enforced.

A K Paikaray, Mahavir Yuvak Sangh, Bhubaneswar

Water pollution may be due Fluoride or Arsenic contamination in Orissa state. Although it may be useful to discuss the technical issue related to arsenic limit in drinking water in Orissa, there is also a social angle related to health impacts that needs immediate action. I would recommend contacting Prof. Khuntia of R R L Bhubaneswar(CSIR) for more information on this topic.

D K Raut (MBBS, MD, FIPHA), Department of Epidemiology, All India Institute of Hygiene & Public Health, Kolkata

It is great to see lot of responses to query raised by Nupur. I would like to state that though arsenic toxicity is a environmental issue that affect not only health but also socio-economic development. I am working on Arsenic health effects over 10 years in West Bengal where arsenic contamination problem is rampant, and observed that even after knowing that arsenic over 50 ppb causes health effects people are still drinking arsenic contaminated water above these levels. It is a matter of great concern that still we are unable to provided safe drinking water to our people. Hence, reducing arsenic levels below 20 ppb or 10 ppb for drinking purpose is again a matter of academic interest which neither a state or central govt. can afford. In West Bengal there are 79 blocks in eight districts that are arsenic affected and over 14 million people are at risk of arsenicosis. Efforts are being made by state govt.AIIH&PH and other agencies to provide safe drinking water by using deep tubewell, arsenic removal plants, arsenic removal filter and also piped water supply where ever it is possible. We can also think about rain water harvesting and use of surface water after necessary purification which is comparatively arsenic free.

D Chakraborti, School of Environmental Studies, Jadavpur University, Kolkata

In September 2003, Bureau of Indian Standards (BIS) [Bureau of Indian Standards 2003: ISO 10500: 1991 Edition 2.2 Drinking Water Specification (First revision incorporating Amendments 1 and 2) dated September 2003] has set the desirable limit of arsenic concentration in drinking water to be 10 microgram per litre.

In this regard, Mr. Paul Deverill from UNICEF wrote in a private communication with me (dated August 25), "we are of course aware of the fact that BIS amended the standard for arsenic in drinking water last September, and have discussed the implications of this change with RGNDWM, NICD and WHO, among others. We are waiting to hear from BIS and CPHEEO on how this standard should be interpreted, given the lack of testing capacity in the affected states."

Recently, in a publication (http://ist-socrates.berkeley.edu/~asrg/04SmithAsDWRegulations.pdf), Smith and Smith have remarked in the concluding sentence, "However it might be advisable to make the Guideline 50

microgram per litre for developing countries with widespread population exposure currently above 50 microgram per liter."

We have some strong objections against Smith and Smith's recommendation of 50 microgram per litre of arsenic in drinking water. Please find our commentary on this subject (http://www.solutionexchange-un.net.in/environment/cr/res05090503.pdf), along with related articles (http://www.solutionexchange-un.net.in/environment/cr/res05090501.pdf; http://www.solutionexchange-un.net.in/environment/cr/res05090502.pdf). In the former, we have argued: (a) undernourishment increases arsenic effects, (b) WHO recommended guideline value is accepted in almost all developed countries, (c) daily water intake of people in the arsenic affected areas in tropical countries in India and Bangladesh (there are differences in lifestyles as well) and (d) differences in metabolism in of arsenic in infants, children and adults could be responsible for the differing susceptibilities between these sub-populations.

We do understand the major difference between 10 and 50 micrograms/litre, in terms of removal strategies especially the financial burden to the government. Fixing a higher guideline may also seem comfortable as there are constraints in measurement of arsenic levels below this level, and the arsenic removal plants installed in different parts of West Bengal have reported removal of arsenic below 50 micrograms/litre but not 10 micrograms/liters.

In the wake of the above circumstances, it may happen that the BIS reverts back to 50 microgram per litre arsenic standard. However, the limitations need to be understood and attempts made to overcome them.

Ruchita Khurana, Toxics Link, New Delhi

This is regarding your query on arsenic levels in water. I am mailing you a paper by Dr. Dipankar Chakraborti, establishing the link between exposure to arsenic in relation to the limits stipulated for arsenic containment. Dr. Chakraborty is associated with School of Environmental Studies at Jadavpur University, Kolkata and has been deeply engaged in various research works on arsenic contamination in water.

The paper specifically mentions that it is not justified to declare 50 ppb as safe arsenic limits, more so in rural environment where undernourishment is too an issue. Undernourishment aggravates the risks of arsenic effects. I am mailing you another paper by Soma Mitra that highlights the link between malnutrition and risk of skin leisions due to arsenic contamination.

Dr Chakraborti's paper also highlights the fact that arsenic contamination is highly undermined since the intake of arsenic is not only through drinking water but also through cooking and agricultural irrigation resulting which arsenic tends to enter our food chain.

Many thanks to all who contributed to this query!