6th International Conference on

"Safe Water and Safe Food Options in Arsenic Mitigation: Lesson Learnt"

4th – 5th January 2006, Dhaka, Bangladesh
Venue: Dhaka Community Hospital Auditorium

Conference Details

Jointly Organized By:

School of Environmental Studies, Jadavpur University, India
School of Public Health, Harvard University, USA
CRAR, University of South Australia
Dhaka Community Hospital

Contents

Programme

Time	Particulars
Day -1: 4th January 2006	
08:15am to 08:45am (30 Minutes)	Registration
8:45am. To 11am	**Opening Session**
09:00am to 9:05am (5 Minutes)	Recitation from Holy Quran
09:05am to 09:10am (5 Minutes)	Prof. Quazi Quamruzzaman to Introduce Participants
9:10am to 09:40am (30 Minutes)	Dipankar Chakraborti - Major issue to be addressed to combat arsenicosis in Ganga - Meghna - Brahmaputra Plain
09:40am to 9:50am (10 Minutes)	Prof. Mahmuder Rahman - Conference theme.
09:50am to 10:10am (20 Minutes)	General Discussion on conference theme by participants and major issue.
11:00am to 11:15am	**Tea Break**
Paper Session - I **(11:15am - 12:30)**	**Water options and Safe Water use** **Opening remarks: by Chair person/co-chair**
11:15am to 11:25am (10 Minutes)	Prof. Md. Mujibur Rahman - Rain water Harvesting as an alternative
11:25am to 11:40am (15 Minutes)	Prof. Ainun Nishat - Are we serious about surface water options
11:40am to 11:50am (10 Minutes)	Dr. Abul Hussam - "Groundwater Arsenic filter based on Composite Iron Matrix: Performance and Large Scale Deployment Studies"
11:50am to 12:00 noon (10 Minutes)	Dr. Alauddin - Chemical fate of Arsenic and other trace elements in deep aquifer water of Bangladesh
12:00 to 12:10pm (10 Minutes)	Meera M. Hira Smith "Data management of the project well" dug well programme
12:10pm to 12:20pm (10 Minutes)	Prof. M. Fakhrul Islam (RU) "Chulli Purified water"
12:20pm to 12:30pm (10 Minutes)	Ryuji Ogata (JICA) "Water Quality of safe water in Dry season and Rainy season"
12:30pm to 01:00pm (30 Minutes)	Discussion and Summing up by Chairperson
01:00pm - 01:40pm	**Lunch Break**
Paper Session - II **(1:40pm - 2:45pm)**	**Arsenic contamination and its impact on food chain, Soil and Environment.**
1:40pm to 1:45pm (5 Minutes)	Arsenic contaminated Ground Water and Agri-output and Environment - opening remarks by chairperson/co-chairperson
1:45pm to 2:15pm (30 Minutes)	Ravi Naidu - "Potential arsenic exposure pathways in Bangladesh"
2:15pm to 2:25pm (10 Minutes)	Prof. Imamul Huq - Arsenic in food chain
2:25pm to 2:35pm (10 Minutes)	Ms Nasreen - " GIS base Risk Model for Arsenic Contaminated Landscape"
2:35 pm to 3:00pm (25 Minutes)	Discussion and Summing up by Chairperson

Time	Particulars
Paper Session - III **(03:00pm to 04:0pm)**	**"Arsenic Poisoning and Health Issues"**
3:00pm to 3:05pm (5 Minutes)	Opening Remarks - by Chairperson/co-chairperson
3:05pm to 3:20pm (15 Minutes)	2. David Christiani - Sex specific protective effect of hemoglobin on arsenic-induced skin lesions
3:20pm to 3:30pm (10 Minutes)	Dr. Md. Shahidullah Sikder "Management of Arsenicosis"
3:30pm to 4:00pm (30 Minutes)	Discussion by participants and comments by chairperson
4:0pm to 4:15pm	**Tea**
04:15 pm - 05:25pm	**Closing Session:**
4:15pm to 4:25pm (10 Minutes)	1. Ainun Nishat/ Prof. Mahmuder Rahman - Addressing the Points focused and issues raised in sessions.
4:25pm to 4:35pm (10 Minutes)	3. Abul Kashem - Secretary / LGRD GoB Views of Government of Bangladesh and Action Plan in Arsenic Mitigation and safe water
4:35pm to 4:55pm (20 Minutes) Views of Opinion from leading media Personally	4. Mafuz Anam/Nurul Kabir/Mahbub Alam on Role of Media, in implementing sustainable water management policy and points raised in the sessions.
4:55pm to 5:10pm (15 Minutes)	5. Prof. Ainun Nishat - Summing up of the conference sessions
5:10pm to 5:15pm (5 Minutes)	6. Prof. Mahmuder Rahman - Dhaka Declaration
5:15pm to 5:25pm (10 Minutes)	Prof. Quazi Quamruzzaman - Chairperson Concluding remarks and vote of thanks

6th International Conference on "Safe Water and Safe Food Options in Arsenic Mitigation: Lesson Learnt"

Conference Overview

Prof. Mahmuder Rahman[1]

This conference, the 6th International meet, is participated by you, who are involved directly or indirectly in formulating, advising and focusing on issues mitigations options in response to arsenic contamination of drinking water in Bangladesh. Some of us present here today are also engaged in research activities involving water soil and food chain contamination of arsenic and some are working to understand its effect on Health. **The aim of this conference is to look back over the last 10 years and learn from the accumulated knowledge, from the successes and failures, advantages and disadvantages of mitigation options and also from various action programmes and mitigation strategies carried out by agencies and organisations in the arsenic contaminated areas.** This conference also aims to identify the further needs and suggest ways to address the needs and help to focus on sustainable and affordable mitigation activities for future.

In February 1998, our first International Conference, the first Dhaka Declarations stated that in Bangladesh groundwater is contaminated with high concentration of arsenic and the cause of this contamination is geological. We also declared that large number of people and children are suffering and in future there will be more suffering unless we addressed the massive poisoning as an emergency and suggested that all available knowledge and skill regarding safe water and patient management be shared with communities suffering from these problems. Community based, affordable and sustainable safe water options should be implemented urgently to mitigate this impending calamity. And we proposed that Bangladesh should have a watershed management policy.

In our 2nd International conference December 1998 participants voiced the need and urgency of correct evaluation of the arsenic problem and **proposed that the problem has grown beyond the drinking water and research is required to understand its effect on food chain, soil and environment.**

[1] Trust Coordinator, Dhaka Community Hospital.

In the 3rd International Conference on arsenic in May 2000 the participants focused on the need of arsenic patient management and asked all agencies government and non-government, donors and academic bodies to **work for social mobilization and involve the local government bodies and village communities and empower them to implement mitigation activities.** They also recommended the need of tapping indigenous knowledge and resources available to use various water sources and validate the safety of such water sources by scientific methods and also **helps the communities with knowledge and skill so that alternative water options and traditional water uses are made safe as sustainable option to aquifer water which is contaminated with arsenic.**

In the 4th International Conference in January 2002 the participants of that conference in their declaration voiced the importance of developing a **uniform, acceptable "Arsenicosis" case definition** resulting from chronic arsenic poisoning and also the **need for a case management protocol** for thousand of patients suffering from arsenic poisoning. In this conference the participants also declared that countries like Bangladesh being endowed with abundance of surface water and **rain water, all available resource and knowledge must be made available in order to use surface and rain water before suggesting groundwater withdrawal except unavoidable circumstance or in the areas recognized as safe areas for aquifer water extraction.** In matters related to water sources management the participants further advised that **great caution and care to be taken before recommending any solution as alternative source of safe water by proper scientific evaluation.** It is important not to create another massive problem by making some recommendations which in future may result in a similar crisis from lack of understanding or from carelessness. The participants also recommended **concern about groundwater extraction and suggested that extreme safety measures must be ensured not to contaminate deep aquifers.** In affected areas, groundwater extraction from shallow aquifers be stopped and alternative water source like dug-well, river and pond sands filters and rainwater harvesting should be implemented as safe water sources. Your advised also helped to develop Arsenic Mitigation Policy of Bangladesh.

In the last (5th) International Conference in Feb. 2004 the participants of the conference urged that **All agencies should adhere to the national arsenic policy and implementation plan as approved by Government of Bangladesh.** They observed and expressed concern about safety of deep aquifers and advocated for adequate technical skill and proper understanding of the geological parameters before large scale extraction of Deep aquifers water sources. They also recommended **3rd party audit and**

analysis of all deep tube-well installed by government and non-government bodies from 1997 onwards in order to monitor water quality. This is important as reports from Bangladesh and West Bengal, India suggest that deep tube-wells are also getting contaminated with arsenic. Participants also took note of the **failures of arsenic removal technology in various hydrological regions** and strongly recommended further independent scientific scrutiny before validating such technology for wide spread uses and marketing (sludge management reliability of cost-effectiveness and its long term effect on soil and environment). The participants further recommended the importance of ensuring active participation and ownership of local communities over options and active involvement of local bodies and institutions before during and after implementation of the programme.

In summery the previous 5 conferences highlighted the following bullet points:

- Arsenic contamination is a massive Public Health problem of unprecedented magnitude and needs to be addressed urgently and properly.
- Arsenic contamination also is an Environmental Problem and research is needed to understand its long term effect on soil and food chain.
- Countries like Bangladesh are blessed with surface and rainwater, therefore all efforts are to be made for surface water use and rainwater harvesting before extraction of aquifer water.
- Third party evaluation of deep tube-well to assess its quality and ensure proper care when tapping deep aquifers for extraction.
- Resource allocation for arsenicosis patient management and uniform care and rehabilitation for affected person to be ensured.
- Health providers are to be trained uniformly to identify and manage Physical, Mental and Social Well-being of arsenicosis cases.
- In arsenic affected areas, shallow aquifer water extraction be stepped and safe surface water use to be encouraged activity by all stakeholders.
- Arsenic contamination is not only a drinking water problem but also may become a long-term environment hazard including food-chain contamination.
- All agencies need to follow the National Arsenic Mitigation Policy and action plan with utmost sincerity.
- Sufficient resource allocation is necessary for alternative water options including behavioral change and advocacy.

Activities and Achievements in the past years

- In the past years after considerable discussion and deliberation government of Bangladesh has recognized arsenic contamination of groundwater is a major health problem and **formulated an Arsenic Mitigation Policy and Mitigation Action Plan** to counter this massive calamity. This policy and action plan highlighted the following points
- The policy and implementation plan is to **ensure co-ordinated activity by all stakeholders.**
- There is no knowledge to control at source of contamination and no proven treatment of arsenicosis. Hence the primary option is alternative supply of arsenic free water.
- Arsenic in groundwater may also affect on agriculture and food chain.
- Screening and regular monitoring of all tube-wells including irrigation wells.
- Identify all arsenicosis patients (Prevalence Study) and developed effective management protocol.
- Give preference to surface water and rainwater to groundwater except in safe areas.
- Provision for treatment at different levels of service delivery and referral chain.
- Providing for Rehabilitation for Patient.
- Capacity Building - field kit development and lab support.
- Capacity at local community level for installation and operation of alternative water sources.
- Research and development of water options, study of deep aquifer and patient treatment.
- The Government also formulated a committee headed by secretaries of all related ministries chaired by principle secretary of the Prime-minister to overview all activities on Arsenic Mitigation. This committee also is assisted by a national Experts Committee on technical matters and assist in implementation plan.
- International agencies like World Bank, UN Agencies like WHO, UNICEF and Donors started to recognise the problem of Arsenic contamination and contributed significantly in various mitigation programmes.
- Some steps are taken by government agencies like DPHE and UN agencies like UNICEF in collaboration with Private organisations and NGOs to promote surface and rainwater as alternative safe water sources.
- Ministry of Health in collaboration with other organisation started to train health workers to identify arsenicosis cases and is working on ways and means to help arsenicosis patient

- WHO developed a protocol for an arsenicosis case management and case definition with regional experts for identification of Arsenicosis and a management protocol.
- Private and Public organisation and academic bodies started various action oriented research and laboratory investigation (scientific research) for patient management.
- Research is carried out and are in progress for the understanding of long term effect of on food chain, soil and human health due to arsenic contaminated of aquifer water and its ill-effect on health.

Observation

Areas needs to be investigated (knowledge gap) and properly understood which may help future action programme.

- Various other deltaic regions of this part of the world starting from Sinth delta in Pakistan to Mekong delta in Vietnam and beyond, are said to have arsenic in their aquifer water with various degrees of contamination.
- Working with alternative water sources we experienced that various other countries of the world where surface water as well as groundwater is not easy to get, rain water harvesting and stroing for household use and also for recharging the aquifer are done successfully even though annual rainfall in some of this countries are much less than that of Bangladesh.
- Our experience with dug-well suggest that it is a good option as an alternative water source. Some anxiety about its quality due to contamination with micro organism was reported. Our organisation (DCH) is actively engaged to address this problem of bacterial contamination and have developed a maintenance protocol. Further skill and resources are necessary to implement the protocol and make this particular option safe.
- We also observed that Bangladesh have 30,000 (thirty thousand) miles of river along with many more thousands of other water bodies. Large number of this water bodies are is arsenic affected areas". Some organisation started to supply safe water from this water sources by simple means like sands filters at a community level and results are encouraging. Resource allocation and mindset change of agencies and community is necessary to implement this option.
- Working with other agencies both in public sector, UN agencies and donors, we observed that the government approved mitigation policy and action plan are yet to be followed in sprit and action. There are attempts to undermine some alternative options without proper evaluation.

- We also witnessed various research activities are on progress in the field of Arsenic Patient Management, though no cure is yet in sight. However arsenic free safe water still remains the main mitigation activity for arsenic affected people.
- The agencies need to come up with more resources in the field of patient management and particularly programme like arsenicosis case prevalence study and funds for research for better understanding of long-term effect on Health and Environment due to arsenic contamination of groundwater.

Concerns

- We also noticed inadequate support by donor agencies in patient management. There are still gaps in information gathered on health issue.
- Confusion still exists in proper use of water resources as mind-set change from aquifer water to surface water use, dug-well and rain water harvesting need to be addressed.
- Public sector agencies like DPHE and other bodies are yet to plan and implement large scale, long term and sustainable programmes for the vast surface water use and rainwater available for both drinking household and irrigation purpose and minimise dependency on groundwater (aquifer water).
- Adequate resources are not available for alternative and sustained programmes for surface water and rainwater storage for long term use for drinking, household use and for irrigation.
- International agencies like World Bank, UN agencies as well as donors are yet to allocate sufficient resource to rainwater and surface water use either because of lack of large scale public sector programmes for surface water use or because of their lack of understanding of the Bangladesh problems and its potentials.
- Some national and international NGOs are implementing large programmes in safe water with large amount of donor funding without submitting it for review by particular lead ministry, which is necessary for co-ordination and minimising duplication of activities.

Risks

- We are still witnessing tube-well are being installed in high-risk areas without proper monitoring of water quality.
- No 3rd party evaluation of deep tube-well regarding quality of water.
- No resource allocation to undertake scientific evaluation leading to safety of surface water use by sand-filter, rainwater harvesting and dug-wells.

- No significant resources are allocated by development partners in patient management, patient identification and research on Arsenicosis.
- There are indications which suggests that some stakeholders in the field of arsenic mitigation are not acting according to Government approved mitigation policy and action plan and are failing to understand that sprit and content of the policy.

Possibilities

- By implementing programmes based on rational use of available rain and surface water and reducing dependency of aquifer water it will be possible to mitigate the impending natural calamity of arsenic poisoning.
- Better and long term water resource management will open many opportunity in health, agricultural and financial section and make positive impact on poverty alleviation and thus furthering millennium development goal.
- In the field of health, proper research will bring new hope for complicated arsenicosis patients and open better understanding of the disease process and effects of other co-factions.

I therefore call upon all concerned and particularly to the participants of this conference, to give clear direction to the points highlighted in the past years for sustainable water use. We hope there will be constructive discussion to suggestions and indicates the importance of sustainable need based mitigation programme and research for better understanding of food chain contamination and safety of environment due to massive withdrawal of arsenic contaminated aquifer water.

Learned participants, some of the points raised in my deliberation may appear to be tall-order for a country like Bangladesh but I like to mention that a calamity of this magnitude must be addressed properly to save our future generation. To achieve meaningful success from this massive calamity we may have to sacrifice short-term gains for more lasting and long-term sustainable achievements and for a healthier future. So let us come forward and openly discuss, make constructive criticisms and suggest safe and sustainable activities and programme to strengthen the arsenic mitigation policy and implemental plan. We must not forget, resource invested in water is going to give more profitable return that most of other investment. Let me end with the quote “Water is not essential for life it is Life”.

Major issues to be addressed to combat arsenic crisis in Ganga-Meghna-Brahmaputra (GMB) plain

***Amitava Mukherjee[3], Dipankar Chakraborti[1]**, Mrinal Kumar Sengupta[1], Sad Ahamed[1], Md. Amir Hossain[1], Mohammad Mahmudur Rahman[1], Bhaskar Das[1], Dilip Lodh[1], Bishwajit Nayak[1], Subhash Chandra Mukherjee[4], Shyamapada Pati[5], K.C. Saha[6], R.N. Dutta[7], Garga Chatterjee[2]*

Quazi Quamruzzaman,[6] Mahmuder Rahman[6], Shibtosh Roy[6], Imrul Kaies[6], Md. Golam Mostafa[6], Md. Aruful Islam[6], Salim Morshed,[6] Farzana Bagum[6], Md. Jadeb Yousuf,[6]Salim Morshed,[6]Tanzima Islam,[6] Khandokar A. Asad.[6]

During our last 17 years of survey in GMB plain (Figure 1) we identified 5750 arsenic affected villages. The GMB plain includes the following states in India: Uttar Pradesh (UP) in the upper and middle Ganga plain, Bihar and Jharkhand in middle Ganga plain, West Bengal in lower Ganga plain, and Assam in upper Brahmaputra plain. Bangladesh falls in Padma-Meghna-Brahmaputra plain. We analyzed 1,45,000 and 52,000 tubewell water samples from India and Bangladesh respectively with FI-HG-AAS. In India 48.7% water samples had arsenic concentration above 10 ppb and 23.8% above 50 ppb; In Bangladesh these values were 43.0% and 31.0% respectively. Almost 9 million people in India was drinking water with more than 10 ppb arsenic and 7 million people with more than 50 ppb arsenic, while in Bangladesh the affected population were 52 and 32 million respectively. Importantly a good proportion of the people could be sub clinically affected.

So far we have screened 1,42,000 people including children (below 11 years age) with our medical team for arsenic toxicity. Almost 9.89% (n= 1,23,000) of the patients screened from India (which include our recent survey in Bihar, UP, Jharkhand) showed arsenical skin lesions while in Bangladesh the ratio was 19.8% (n=19,000). Another worrisome fact is, our previously reported study showed that within a span of 3-7 years many village tubewells which were safe (arsenic <10 μg l^{-1}) are getting contaminated now (arsenic >50 μg l^{-1}) and arsenic concentration in many tubewells has increased by as much as 5-20 fold. Therefore it appears that a good proportion of all the states and countries in the GMB plain comprising an area of 5,69,783 sq. km and a population of over 500 million may be at risk from groundwater arsenic contamination.

A few million US dollars have already been spent and millions being spent in the ongoing projects on field kits to classify tube wells delivering arsenic below 50 μg/L (the recommended limit in developing countries) as safe, painted green or above 50 μg/L, unsafe and painted red. Field kits have tested more than 1.3 million tube wells in Bangladesh alone. However, the reliability of the data generated through field kits is questionable.

Installation of hand tube-well attached arsenic removal plant in the affected areas is one of the alternative ways to provide safe drinking water to the people. But the experience of ARPs is not at all satisfactory to recommend it as a mitigation means. In our extensive survey on arsenic removal plants installed in different parts of West Bengal-India at an expense of millions of dollars, we have noticed that, though some of the plants could remove arsenic below 50 μg/L levels, none of them could bring down arsenic level below 10 μg/L.

Furthermore, considering the plight of children in the arsenic affected regions of West Bengal and Bangladesh the case would be more evident. Infants and children are often considered more susceptible to the adverse effects of toxic substances than adults Differences in metabolism of arsenic in infants, children and adults could be responsible behind differing susceptibilities between these subpopulations. In one of our studies on an arsenic affected population in Bangladesh we have found that second metabolic step in arsenic metabolic pathways is more active in exposed children in comparison with exposed adults.

In arsenic affected areas of West Bengal and Bangladesh arsenic contaminated water is not only used for drinking and cooking but also for agricultural irrigation. Thus arsenic comes into the food chain. It has been estimated that from a single block Deganga in North 24 Parganas (area 200 sq. km) 6 tons of arsenic from 3200 irrigation tubewells is falling agricultural fields. Our speciation studies revealed most of the arsenic in rice and vegetables is in inorganic form.

In September 2003, BIS (Bureau of Indian Standards, 2003) set the desirable limit of arsenic in drinking water to be 10 μg/l (yet to be accepted by Government of India). In repercussion, in concluding remarks of a recent publication in Toxicology (Smith, A. H. and Smith, H. M. 2004) which discussed about implications of drinking water standards in developing countries especially on magnitude of cancer risks, the authors suggest to raise the guideline value to 50 μg/l in case of developing countries. In the same article the authors stressed how malnutrition plays a significant role in increasing the risk of arsenicosis. Thus a large section of population living in villages in India and Bangladesh are more susceptible to the danger of arsenic. Epidemiological studies ascertain that drinking water with As concentration between 0.01 to 0.05 mg/l for more than 10 years could produce pigmentation and keratosis in some people. It is also noteworthy that EPA calculated the standard value on basis of 1.2L/day water intake value while in case of WHO standards the value was taken as 2L/day. In our extensive survey

on a population in a village in West Bengal we have calculated that average volume of water intake per day for adult males, adult females and children is 4L, 3L and 2L respectively. This value can be extrapolated to vast region of West Bengal and Bangladesh considering hot and humid climate prevailing there. This value excludes arsenic inclusion into body burden through food chain. It is also been highlighted in literature that the cancer risks might be of the order of as high as 1 in 100 for 50 μg/l.

To understand how effective are the million dollar mitigation programs undertaken in Bangladesh, we made a comparative study in Eruani village (PS: Laksham, Dist: Chandpur) in two different time periods once in the year 1998 and again in 2004 during the fifth International arsenic conference held in Dhaka. During these surveys we collected hand tube well water samples and biological samples for arsenic analysis and our medical team screened villagers for identifying arsenicosis patients. Our analytical results indicate that the arsenic contamination situation and consequently the sufferings of the villagers of Eruani have rather aggravated over a time span of 6 years despite spending more than 100 million dollars for arsenic mitigation in allover Bangladesh.

To combat the present arsenic crisis in the GMB basin we urgently need to consider the following options. West Bengal, India and Bangladesh are called the lands of rivers. During the monsoons, when the average annual rainfall in these regions is about 2000 mm, the rivers are abundantly fed. In addition, there are other available surface water resources such as wetlands, flooded river basins, lagoons, ponds and ox-bow lakes. The per capita available surface water in Bangladesh is 11,000 cubic meters and in arsenic affected areas of West Bengal about 7,000 cubic meters. Instead of sinking tubewells and pumping out underground water without any test, oversight or regulations, the use of surface water needs to be seriously considered. One of the long-term solutions may be digging deep tube wells, which extract from aquifers 200 meters or further below. Deep tubewell is a source of arsenic safe water and possibility of arsenic contamination is less if the deep tube well construction is done properly and the aquifer tapped is underneath a thick clay barrier. In case of deep tubewells we must test for the other contaminants. Alternative safe water sources such as dug-wells and rainwater harvesting with controls for bacterial and other chemical contamination need to be implemented. Above all, the villagers in the affected areas need to be educated about the existence, magnitude, danger and sign and symptoms of the arsenic problem.

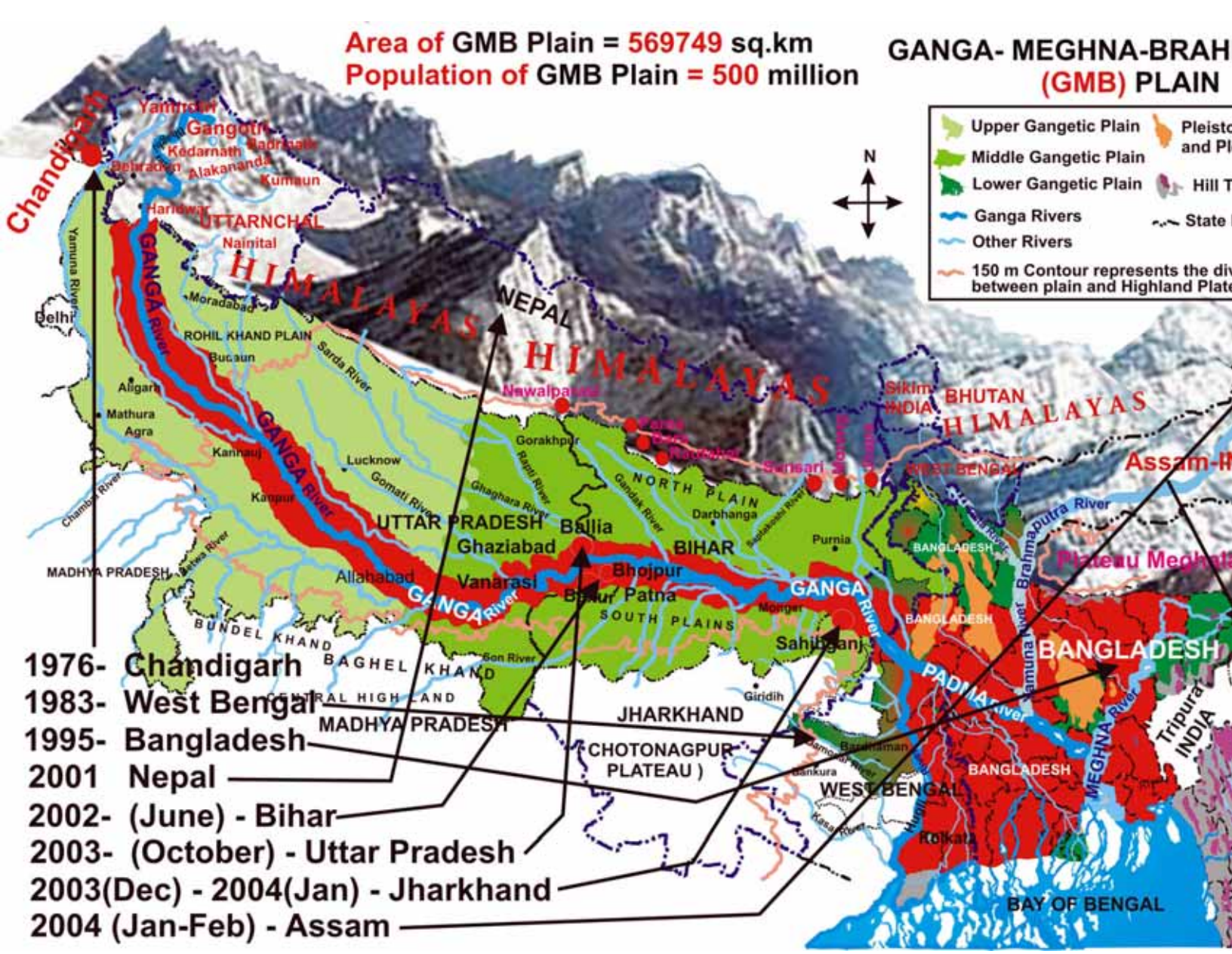
Area of GMB Plain = 569749 sq.km
Population of GMB Plain = 500 million
GANGA- MEGHNA-BRAH
(GMB) PLAIN
Upper Gangetic Plain
Middle Gangetic Plain
Lower Gangetic Plain
Ganga Rivers
Other Rivers
150 m Contour represents the div
between plain and Highland Plate
N
Chandigarh
Yamunotri
Gangotri
Badrinath
Kedarnath
Alakananda
Kumaun
Haridwar
UTTARNCHAL
Nainital
HIMALAYAS
NEPAL
Delhi
Moradabad
ROHIL KHAND PLAIN
Bucaun
Sarda River
Aligarh
Mathura
Agra
Kannauj
Lucknow
Gomati River
Kanpur
Chambal River
MADHYA PRADESH
Etawa River
Allahabad
GANGA River
UTTAR PRADESH
Ghaziabad
Ballia
Vanarasi
Bhojpur
Bihar
Patna
Gorakhpur
Ghaghara River
Rapti River
Gandak River
NORTH PLAIN
Darbhanga
Nawalparasi
Sikim
INDIA
BHUTAN
HIMALAYAS
Sunsari
Purnia
Assam-H
Brahmaputra River
BANGLADESH
Plateau Meghal
SOUTH PLAINS
BUNDEL KHAND
BAGHEL KHAND
Son River
CENTRAL HIGH LAND
Sahibganj
Giridih
JHARKHAND
CHOTONAGPUR
PLATEAU)
Barddhaman
Bankura
WEST BENGAL
Kolkata
PADMA River
Jamuna River
MEGHNA River
Tripura
INDIA
BAY OF BENGAL
1976- Chandigarh
1983- West Bengal
1995- Bangladesh
2001 Nepal
2002- (June) - Bihar
2003- (October) - Uttar Pradesh
2003(Dec) - 2004(Jan) - Jharkhand
2004 (Jan-Feb) - Assam

Figure 1

Rainwater harvesting as an alternative water supply option for arsenic affected areas in Bangladesh

Dr. Md. Mujibur Rahman
Professor of Civil Engineering, BUET, Dhaka

Since the detection of excessive arsenic in shallow groundwater aquifers in early nineties, efforts are being made by different organizations to develop and promote alternative safe water supply options for people in the affected areas. Options like rainwater harvesting, shallow dugwells, filtering pond and river waters are being tried with varying success. The immediate challenge is to assess these technological options in terms of their technical feasibility, economic viability, social acceptability and environmental sustainability. Rainwater harvesting system, which has been widely used in many parts of the world, possesses a great potential in addressing today's real challenge of acute arsenic poisoning in different parts of the country.

This article is based on an evaluation of an action research project that focuses on important parameters including rainwater quantity, i.e., the supply and demand, rainwater quality, operation and maintenance, system cost and social acceptability. The action research project clearly identifies rainwater harvesting as a potentially safe, reliable and affordable alternative source of water supply for drinking and cooking for at least 8 – 10 months of the year. The project reveals that the cost of rainwater harvesting can be brought down to affordable limits of people when used in combination with another safe communal water source for about 2 – 4 months during the dry spell of the year. The supplementary community water source could be an arsenic free tube well, pond sand filter, a protected dugwell, or even a large community rainwater reservoir. It is however, important that such safe community water sources are available at reasonable distances.

This action research project has clearly demonstrated that proper collection and storage of rainwater can solve the acute problem of safe drinking water in arsenic affected areas, and that motivation and training has a key role in the success of the project. Continued efforts in capacity building of the local entrepreneurs and of the users can bring total confidence in people that household rainwater harvesting system in combination with an appropriate community water source is a sustainable safe water supply option. Other important conclusions drawn from evaluation of the action research project are as follows.

- The rainwater can be stored in tanks, jars or pots of different sizes and materials of varying costs to match individual household's need and affordability.
- The household rainwater harvesting system in combination with a suitable communal safe water source can save a tremendous amount of productive time of people for a large part of the year (8 – 10 months).
- Operation and maintenance of rainwater harvesting is very simple and can easily be done by the caretaker or even by any member of the family, and costs could be as little as Tk. 20/- per year for a household unit.
- Simple cleaning of roof catchment before rain events, flushing out of the first 5 – 15 minutes rainwater (depending on the rainfall intensity, and using the simple first flush outlet device) before each rain event, and occasional bleach washing of the storage reservoir, may provide bacteria free, safe drinking water to people.
- The quality of stored rainwater is well accepted by people of the project area, which according to the users, are beneficial in preserving cooked food for a longer period.
- Motivation, monitoring, evaluation and follow up should be a continuous process in order to achieve long term sustainability of rainwater harvesting system.

Surface Water as source of safe drinking water

By
Ainun Nishat and H S Mozaddad Faruque

In Bangladesh there is overabundance of surface water in the monsoon season but it becomes a scarce resource in the dry season as users (both inside and outside the country) compete to satisfy variety of their demands with these resource. Volume of river flows available during seven-month period of the dry season (November- May) is around 10-20 percent of the average annual transboundary inflows. However its distribution in space and time is a constraint to the development of surface water based dependable water supply system without interventions. Apart from the surface water inflows through border rivers, on an average we have 2360 mm of rainfall annually distributed unevenly over time and space. More than eighty percent of this rainfall is available during the five months June-October) of the year and western part of the country receives less rainfall than other part of the country. There are individual water bodies (e.g. beels, haors etc) that can be used for water supply. These perennial surface water sources including individual water bodies can be utilized with some treatment for piped distribution system both in the urban and rural areas.

The bulk water supply and distribution from surface water sources in the rural areas and towns where local sources are inadequate for use is a medium to longer-term possibility. Perennial rivers, mostly the major rivers and their distributaries would be the surface water sources. If main river barrages are built, the network of possible distributaries would be considerably increased. Perennial rivers could serve many villages, but the capital cost and also cost of supply would be high. Capital cost would be less where water is being conveyed for irrigation through open canals. It will however be possible to recover the cost of conveyance through weekly/monthly payments under an arrangement demonstrated by Barind Multipurpose Development Authority (BMDA) in the Barind Tracts. The entire Southeast and a large part of the Southwest and South- central region may be served by this approach.

It is likely that a major shift to bulk supplies from local sources to more distant surface water sources will be required in many cities and towns including Khulna in the near future. Khulna could benefit from increased flows diverted from the Ganges, but may in the meantime abstract fresh water from further upstream. Abstraction from a distant places like from river Jamuna or Padma for Dhaka City may be considered. Augmentation of dry season flows in the distributaris of Ganges and Meghna would be required for Southwest and Southeast region. River water around most of the Major cities is subject to the risk of pollution with consequent difficulties of using it without expensive treatment. River water in any case will require primary treatment particularly the sediment removal and final treatment before it is used for drinking.

Dug well is the oldest method of drinking water supply in rural Bangladesh. The supply source is the surface water stored in the upper layer underneath ground surface that renews annually through flood and rainfall. The technology has been successfully revived with some modification in many parts of the arsenic affected areas.

Traditionally rural water supply to a large extent was based on protected ponds. Due to continuous dependency on the use of tube well, people have been reluctant to use ponds, as biological quality of pond water is poor for variety of reasons. Now-a day ponds are being used

for fish culture and the water have become unsuitable for drinking. Slow-sand Filters, a package type filter unit popularly known as Pond Sand Filter (PSF) have been developed to treat pond water for domestic consumption and has been found suitable by Bangladesh Arsenic Mitigation Water Supply Project (BAMWSP) in many parts of the arsenic affected areas.

Rainwater harvesting during the monsoon has a potential to supplement the demand for drinking water supply in all the arsenic affected areas. The option of rainwater harvesting in the urban areas could be a bit expensive, and acceptance may require some time. It is most likely an appropriate option in coastal areas where both the surface water and groundwater are saline.

This paper concludes with the policy principles and guideline in preparing mitigation plan for adaptation and recommends steps towards enhancing the share of surface water sources in the drinking water supply system in the neat future in Bangladesh.

The surface water resources available for water supply are widely distributed in time and space in the arsenic affected areas. A systematic approach is required for a water supply planning integrated with overall water resources development and management plan.

Groundwater Arsenic Filter based on Composite Iron Matrix: Performance and Large Scale Deployment Studies

Abul Hussam,[1] Abul K. M. Munir[2]

Arsenic poisoning in drinking water is now identified as one of the worst natural disasters. It is estimated that of the 140 million people of Bangladesh, between 77-95 million are drinking groundwater containing more than 50 µg/L (50 ppb or 0.05 mg/L) maximum contamination level (MCL) from millions of tubewells. The only way to solve this crisis is to supply potable water free from arsenic and other toxic impurities. In this endeavor, we have developed and deployed an arsenic water filter on a large scale. In groundwater (pH = 6.5-7.5) arsenic is present in two oxidation states (As(III) in H_3AsO_3 and As(V) in $H_2AsO_4^-$ and $HAsO_4^{2-}$). An ideal filter must remove both species without chemical pretreatment, without regeneration, and without producing toxic wastes. The unit, Sono bucket filter and its predecessor (3-Kolshi filter) have accomplished these qualities. We found that removal of As(III) and As(V) was independent of the input arsenic concentration to 4000 ppb i.e., a zero order reaction. Filtration of more than 394,000 L of groundwater in eight experimental filters located throughout Bangladesh shows water quality parameters meet and exceed USEPA, WHO, and Bangladesh standards with effluent As(total) less than 20 ppb. Results from recent environmental technology verification for arsenic mitigation (ETVAM) data show Sono filter as the most tested and the only filter made from indigenous material in comparison to expensive alumina, cerium ion exchange, and microfine iron oxide based filters. Approved by the Government of Bangladesh (GOB) for household use, about 20,000 SONO filters were deployed in 14 districts in Bangladesh. We estimate that about a billion liter of clean drinking water was consumed from these filters and they continue to provide high quality water for drinking and cooking.

Chemical fate of arsenic and other trace elements in deep aquifer water of Bangladesh

Mohammad Alauddin[1], Margaret Fiasconaro[1], Sarah Alauddin[1], Abul Hussam[2], Maya Bhattacharjee[3], Shamima Sultana[3] and Mohammad Jakariya[4]

Well water samples collected from deep aquifers in two regions of Bangladesh were tested for full range of water quality parameters and compared to the World Health Organization (WHO) guideline values. The purpose of this work is to ascertain deep aquifer water as a viable option to safe drinking water in rural Bangladesh. Additionally, the present work aims at studying the chemical fate of arsenic and other trace elements in deep aquifer water. A combination of analytical techniques (HG-AAS, HG-AFS, GF-AAS, IC) were used to determine 10 elements, 7 anions, pH, hardness and conductivity to study the distribution of components and the data were used in computational chemical equilibrium model, MINEQL+ for detailed speciation of arsenic and other trace elements in deep aquifer water. Arsenic level in most of the water samples were below the WHO guideline value of 10 μg/l. Equilibrium model shows fate and speciation of arsenic and a number of components are linked to the formation of hydrous ferric oxide (HFO). Adsorption and surface complexation is primary mode of species immobilization. Arsenite (As^{3+}), arsenate (As^{5+}), phosphate (PO_4^{3-}) are believed to be fully adsorbed on the HFO. Deep aquifer water seems to be a viable safe water option at this time in Bangladesh.

The Chulli Water Purifier – A novel water purifier

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Introduction:

It is ported by WHO the 80% of all diarrhoeal disease is waterborne. Over the past 20 years in Bangladesh the rural population has become dependent on shallow tube-wells for drinking water and deaths from diarrhoeal disease have been dramatically reduced. Particularly, during the past 6 to 8 years, the drilling of shallow tube-wells has proliferated to the point that it is now projected by DPHE that there may be as many as 11 million tube-wells installed throughout the country. However, dangerous levels of arsenic were discovered to be present in the shallow aquifers and this has rendered much of the ground water undrinkable by WHO and Government standards. It is projected today, that as many as 35 million Bangladeshi Citizens may be drinking this arsenic contaminated water daily and most have no safe drinking water source available to them. With the innovation of the bacteria free tube-wells, the rural population neglected to take care of the ponds and streams, which were their former drinking source and now most of these surface water sources have become dangerously contaminated with bacteria from hanging latrines, animal bathing, etc.

Concept:

The use of ordinary fire wood and other organic fuels used for purifying water thought boiling is effective for killing all harmful bacteria. However, the burning of these fuels can have a serious impact on the environment and the rural poor of Bangladesh cannot afford to buy fuel solely for boiling drinking water. In addition, if normal surface water is boiled and the bacteria destroyed, the clarity of water is not acceptable because people will not have the confidence to drink water that dose not look clean even if it is safe. A simple solution can be reached if the waste heat from the ordinary village-cooking stove made from mud, called ***Chulli***. According to findings by the BCSIR more than 80 percent of the heat produced by the village chulli is wasted to the atmosphere and has no value toward cooking. A small percentage of the total heat generated in the normal village cooking process is all that is required for killing bacteria and if a device could be designed which utilizes the heat from the cooking to simultaneously purify water for drinking, without involving extra fuel cost for the village.

Chemical treatment of water such as chlorine (bleaching powder) and purification tablets is not manageable by the general rural population. Training must be conducted and monitored, as misuse of such chemicals can also be harmful to health. Other issues such as regular availability and distribution also negatively affect the possibility of reaching the remote areas of the country.

The Chulli Water Purifier Technology:

The **Chulli Water Purifier** system makes use of heat that is already being produced in rural households during cooking on traditional clay chulli stoves. The purification process works by passing water to be treated through a hollow aluminum coil, which is built directly into the traditional clay ovens. As water passes through the coil, its temperature is raised to approximately 70-80^0 C, effectively killing the pathogens, which cause diarrhea and other water-borne diseases. After passing through the coil, the heated water is collected in a traditional kolshi and used for drinking purposes after cooling. The system is simple, elegant, and inexpensive, and pre-testing in the laboratory proves treatment was quite effective.

The traditional chulli-cooking stove is made of clay ad after firing, the inside of the chulli behaves like a refractory lined furnace. The temperature of the chulli may reach up to 500*C. The mud walls of the chulli also retain much of that high temperature. The simple aluminum coil is installed in the walls of the chulli stove and the high temperature retained in the walls of the chulli is utilized in the heating of water to kill harmful bacteria. The coil is made of $1/_2$ inch diameter aluminum metal tube and the coil diameter matches the diameter of clay chulli that is about 9 inches. This coil is fixed into the inside mud walls of the chulli stove with the face of the coil exposed directly to the heat generated from the burning fuel.

The **Chulli Water Purifier** system uses simple gravity flow to pass the water through the coil. Feed water is poured into a 20 to 25 liter plastic bucked reservoir, which is placed on a 3 foot high stand made from bamboo. The reservoir contains 10-12 Kg of sand and has a locally made connector fitted in the bottom, which is connected to the input end of the aluminum coil. The sand filtering captures all organics, algae and foreign matter that may be present, clarifying the water before it passes through the coil, Once the heat from the chulli reaches cooking temperature, the operator simply opens the plastic valve and allows the water to drain from the reservoir to the coil. The water is heated inside the coil and exits through the outlet through a plastic faucet.

The water is allowed to pass through the coil at a specified flow rate of 500ml/min and the exit temperature of the water is approximately 70C.

It was observed during the initial research experiments in 2003, that during the ordinary cooking period of I hours, up to 30 liters of clean, bacteria free water could be produced. Obviously, this is much more safe drinking water than is required by the average rural family, but it is also found that one **Chulli Water Purifier** can serve a multi-family barre with up to 4 households.

All fittings, connectors, valve and faucet are made locally, using ordinary heat resistant polythene. The aluminum pipe fro making the coil is also available in the local market.

Many Southeast Asian countries suffering from the chronic arsenic problem also use a similar clay cooking stove and this technology could also be considered for adaptation in those countries.

The following figures show results from bacteria tests before and after passing through the Chulli Water Purifier using water from three different ponds.

Total Coliform Counts/100 ml

	Raw Water	After passing through the Chulli Water Purifier
Run 1	1750	0
Run 2	2500	0
Run 3	560000	0

In view of the very high production rate of bacteria free water from ordinary surface water sources, the **Chulli Water Purifier** has potential application in areas where the ground water is arsenic contaminated but an abundant supply of surface water is available. The **Chulli Water Purifier** can be installed in a metal bucket should also be considered for use in launches, steamers, teashops and restaurants.

Field Testing:

The **Chulli Water Purifier** technology was introduced in 2004 by Integrated Approach for Community Development (IACD), a local NGO focused on the design and development of affordable water and sanitation solution technologies. DPHE/UNICEF has engaged IACD to field-test the Chulli Water Purifier in areas of the country where 90% of all tube-wells are contaminated with arsenic above the acceptable level. Phase I of the project was conducted in Bancharampur Upazilla, Brahmanbaria District and Homna Upazilla of Comilla District. With Professor Islam as project Director, IACD installed 169 Chulli Water Purifier and trained the families in the use of the technology.

Following the successes of Phase I, DPHE/UNICEF decided to expand the project in Bancharampur and introduce the technology to the Jessore District, Manirampur Upazilll. IACD has just finished a Project in 11 Districts and as of Dec. 2005; **2,887** Chulli Water Purifier have been installed within Project Phase I, II and III and some out side than the Project.

All households are impressed by the simplicity of the technology and its ease of operation. The villagers are able to easily maintain the system and feel very secure with the quality of output water. Many families with Rain Water Harvesting Systems also pass their collected rainwater through the Chulli Water Purifier to insure bacteria free drinking water. It should also be noted, that when the heated water exits the Chulli Water Purifier, it pasteurizes the kolshi or container which may also contain secondary bacteria contamination from improper handling.

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Water Quality of Safe Water Option in Dry Season and Rainy Season

Ryuji Ogata,[1] Shamim Uddin

In March 2005, JICA-UNICEF conducted a study on 675 safe water options in emergency response village for arsenic mitigation in Jessore district. The sorts of option for the study are Deep tube well, Dug well, Dug well with Filter, PSF, AIRP, Rain Water Harvesting and Pipe water supply (surface water use). To compare the operational status and the water quality between rainy season and dry season, we conducted another study in October 2005 only on surface and sub-surface water based safe water option.

The percentage of operation status in rainy season was 65% which is relatively better than that in the dry season (57%). Ten parameters (Turbidity, Conductivity, pH, TDS, Salinity, Ammonia, Arsenic, Iron, Manganese, Fecal Coliforms) were measured as the water quality as well as study in dry season. Result of dug well shows high value ammonium in dry season. Heavy metal value such as Iron, Arsenic and Manganese of dug well water in rainy season is relatively higher than dry season. Water quality of other option didn't show much difference between dry season and rainy season in value of ammonia and heavy metals because of using sand filter. Contamination of fecal coliform is found 91% in dug well water, 65% in water of dug well with filter, 87.5% in PSF water. Fecal coliform value of dug well water seems to be affected by turbidity value and chlorination status, but relation was not clearly found between the fecal coliform value and distance from pit latrine or waste storage in this study.

The Absolute Need for Reliable and Simple Measurement

Professor Richard Wilson[1]

Research, practical experience, including unnecessary disappointments and tragedies have emphasized the absolute need for reliable measurements of water supplies at the village level. For deep tube wells, the work of Columbia University and the University of Dhaka have demonstrated the need for measurements of arsenic. For dugwells, rainwater storage and pond sand filters it is necessary to measure coliform bacteria on an even more regular basis. For small scale arsenic removal, maybe we need both. There have been several papers on the unreliability of arsenic measuring "field kits" at the required levels but only one to the presenter's knowledge of how to use them reliably (Columbia University and the University of Dhaka). Worse still the draft IAEA report on comparison of laboratory measurements still stands as a grim warning. Measuring coliform bacteria is easier but equipment from developing countries is expensive. It is also essential that all measurements be publicly available so that others may learn from the successes and failures, I call attention to the modestly priced equipment made by "Clean India" in New Delhi (Dr Ashok Khosla and collaborators).

Risk assessment of arsenic mitigation options: helping to identify how to assure water safety

Guy Howard, Feroze Ahmed, Jafar Shamsuddin, SG Mahmud, Daniel Deere and Annette Davison

A number of water technologies have been identified within the National Policy for Arsenic Mitigation for use in Bangladesh. These include dug wells, pond sand filters, rainwater harvesting and deep tubewells. In providing alternative water sources, it is important that the potential for introducing new hazards is considered and that actions are taken to ensure that options are capable of delivering safe drinking water under all conditions.

This paper summarises the findings of a risk assessment of arsenic mitigation options undertaken with funding from the Arsenic Policy Support Unit. The risk assessment was designed to understand the potential public health risks associated with switching to new water sources and to identify what improvements in design, construction and operation and maintenance are required to ensure safe drinking-water. The risk assessment included water quality analysis and sanitary inspections and a social acceptability assessment. A key element in the project was the development of a quantitative health risk assessment model that allows the potential disease burden associated with different options under different conditions to be quantified. The paper will identify the key lessons learnt and how the findings of the risk assessment can be used in developing arsenic mitigation in the future.

Potential arsenic exposure pathways in Bangladesh

Ravi Naidu[1]*, E Smith[1], Gary Owens[1], Kazi Akter[1], Nasreen I Khan[1], Imamul Huq[2] and Mohammad Rahman[1]

Background

This presentation summarises five years of ACIAR and AusAID funded research on arsenic (As) in Bangladesh. We recognise that geogenic As exposure comes from direct ingestion of As-contaminated water and crops or animal products raised on As contaminated soils. Cycling of As from parent material is through irrigation or surficial transport of soils containing As eg. via erosion or deliberate anthropomorphic activities. The significance of geogenic As ingested through the food route is not known among the many pathways by which As can be absorbed by humans. The list is not complete as it does not consider the possibility of As uptake through inhalation of wind borne dust from eroded As rich soils, by dermal contact through standing in As-contaminated paddy water, nor does it consider potential pathways such as inhaling smoke from the burning of As-contaminated firewood from trees raised using groundwater.

The main pathway for geogenic As is from groundwater to human through the use of groundwater for drinking purposes, and crops (Figure 1).

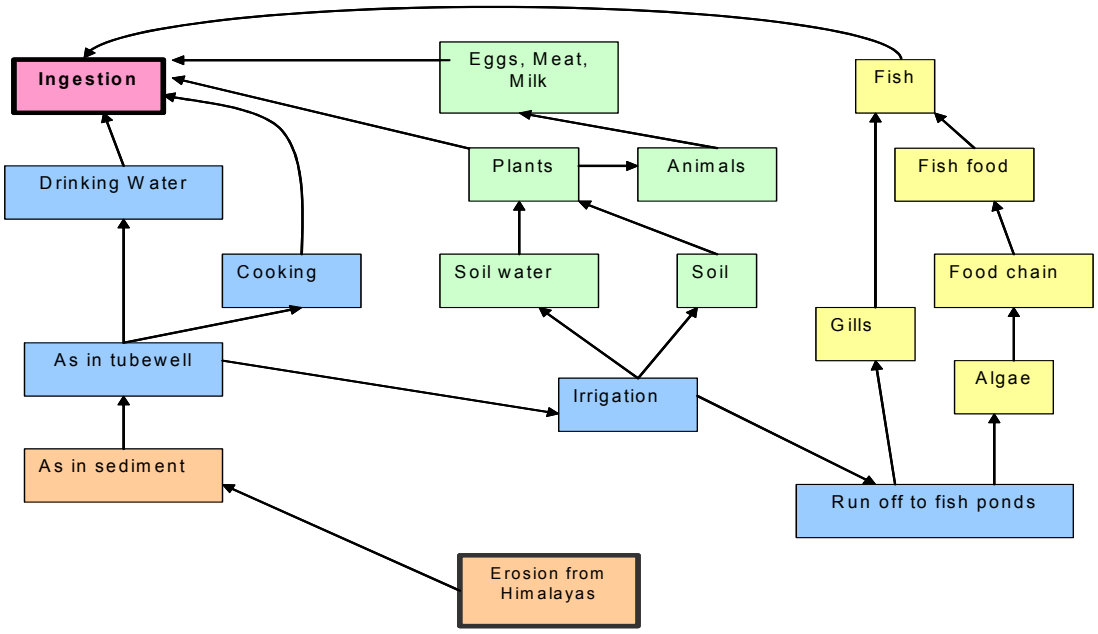

Figure 1 Possible pathways of arsenic ingestion by humans

This paper summarises the As content of vegetables, soil and cooked commonly ingested by Bangladeshi people, including As transfer coefficients and regional variation in bioavailable As.

Plant tissue arsenic

Recent studies have reported a wide variation in plant tissue As content of vegetables and rice commonly consumed by Bangladehsi people. Published literature show As values ranging from <0.05 to > 1.5 mg/kg fresh weight. Our detailed investigations of the As content of plant crops (n = 3000) in Bangladesh shows similar range in the As content of plant tissues. In these studies, we found that the As content of vegetables varied both with plant type and sampling site. About 10% of all samples analyzed showed As concentrations above the permissible 1 mg/kg limit set by Australia's National Health and Medical Council (Figure 2). Green leafy vegetables were found to accumulate a significant amount of As and the highest concentrations were found in cauliflower leaves (6.1 mg/kg) followed by arum (5.2 mg/kg). Surprisingly, amaranthus accumulated little As in plant tissue with only one amaranthus sample from Narayanganj district accumulating 1 mg/kg. In contrats, elevated As concentrations in was arum was found in all of the districts sampled. Arum grows well in the presence of water especially around the tube wells where the soils are often wet and usually contain significantly higher As concentrations than other soils. Elevated levels of As were also found in the leaves of pumpkin, bottle-gourd, and radish, which are part of the daily diet of villagers in the investigated areas. Significant amounts of As are also thought to be absorbed by the skin of most vegetables although the mechanism is not clear.

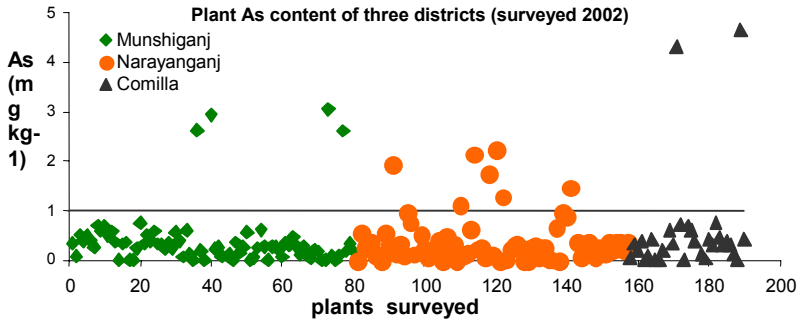

Figure 2. Arsenic content of vegetables from Munshiganj, Narayanganj and Comilla.

In contrast to samples obtained directly from individual farms and households, a market basket survey of rice and vegetables from a number of villages in Bangladesh showed that only a relatively small number of rice varieties and vegetables had elevated levels of As. The majority of rice samples obtained from most markets showed As at concentrations below the level of concern which suggests that rice and vegetables purchased from these markets would not add seriously to the daily intake of As. However, caution must be exercised since most traders import rice and vegetables from either outside Bangladesh or from other villages. This can explain why samples of rice taken from individual households showed As at levels exceeding the safe dose.

Seasonal variation in As uptake by plants may also lead to significant fluctuations in their As content.

Estimation of dietary intake of arsenic from crops

There is little reliable data available to assess the dietary habits of Bangladeshi villagers. In order to do this a detailed survey was conducted on the types, amounts and frequency of food ingested on a daily basis by the Bangladeshi village communities. Our findings from these studies show that up to 30% of the total dietary intake of As may come from ingestion of food although there are extreme cases where food may contribute up to 50% of the total dietary intake of As. The typical As content of cooked food ingested by farmers in Munshigang village is summarised in Table 2. These studies indicate that soil-crop-food transfer, as well as cooking and direct ingestion of drinking water may be one of the major exposure pathways of As to villagers in Munshigang.

Table 2. Concentration of As in cooked food obtained from farmers living in Munshigang village:

Food	Concentration of As (mg/kg)
Rice	0. 11 to 0.35
Egg	< q.l.
Vegetable curry + fish	0.81 to 0.95
Egg plant	0.66 to 1.45
Spinach	0.12 to 0.35
Data Shak (root)	2.5 to 5.23

Bioaccessibility of ingested arsenic

We conducted detailed As bioaccessibility studies using animal feeding trials. Animals were feed a range of As-contaminated vegetables grown under hydroponically in a glasshouse as well as As-contaminated rice grown under paddy conditions. The rice feeding trials also included uncontaminated rice cooked in As-contaminated water. The As content of blood and urine were estimated following ingestion of vegetables by the animals and monitoring continued for 24 hours. These studies show that up to 80% of As present on vegetables and rice could be bioavailable. However, speciation studies indicate presence of inorganic arsenite, arsenate as well as dimethyl arsenic acid in plant tissues which may influence the toxicity of As.

Conclusions

Our studies on As content of commonly grown vegetables and cooked food show significant variations in the As content of plant tissues. However, most of the vegetable As concentrations exceed the Australian Food As guideline of 1 mg/kg dry weight. These data, together with the dietary data and anthopometrical data obtained in this study, indicate that As loads from diet alone at times exceed the maximum daily intake of As.

Arsenic In Food Chain: Remedial Possibilities

S.M. Imamul Huq[1], Ray Correll[2], Ravi Naidu[3], J.C. Joardar[1], Marzia B.Abdulalh[1] and Umme K.Shila [1]

The largest share of As-contaminated ground water goes to irrigation. 85 per cent of the ground water extracted is used for irrigation. About 40 percent of the net cultivable area of the country is under irrigation and of the total irrigation need, 60% is fulfilled from ground water. The major recipient of the irrigation water is the Boro rice along with wheat and some other vegetables crops. In most areas the As contaminated ground water is also used for cooking purposes. Our studies involving field samples, laboratory samples and cooked foods show arsenic accumulation in various degrees in them. An exposure pathway of As ingestion was made using dietary survey data. Daily dietary intake of As was assessed using the amount of biologically available arsenic in various components of the diet and survey data. Together the field data and laboratory studies were used to undertake meaningful simulations of the dietary load.

Generally the dominant source of arsenic ingestion is through drinking water, but there is significant arsenic ingested through the food chain. Five different scenarios, viz., scenario 1: typical diet + water; scenario 2: typical food + 3 L drinking-water; Scenario 3: typical food + 3 L good drinking-water; scenario 4: high As rice diet + 3L drinking-water and scenario 5: high leafy vegetable diet + 3L good drinking-water. Scenario 1 shows the mean As load of the average villager is 161 $\mu g/day^{-1}$ with 104 µg/day coming from the water. Of the remaining 57 $\mu g/day^{-1}$, 49 $\mu g/day^{-1}$ came from rice and 8 $\mu g/day^{-1}$ from vegetables. Scenario 2 shows the average load to be 212 $\mu g/day^{-1}$ with a 6% chance of exceeding the 220 $\mu g/day^{-1}$ limit. Under scenario 3 As load does not present a risk. In scenario 4, the mean load is 304 $\mu g/day^{-1}$ and effectively all cases exceed the 220 µg/day limit. Rice contributed to 144 $\mu g/day^{-1}$, approximately 65% of the 220 $\mu g/day^{-1}$ limit. The scenario 5 is equivalent to scenario 2 but with the typical meal of 152 g of arum eaten every second day. This fairly minor perturbation in the diet increases the daily average load to 219 $\mu g/day^{-1}$, with 25% of cases exceeding the 220 $\mu g/day^{-1}$ threshold.

In fact, simulations indicate that even when uncontaminated water was used for both drinking and cooking, that in about 30% of cases the Maximum Allowable Daily Level of 220 µg arsenic was exceeded due to contaminated food alone.

Several remedial measures including mixing of fresh water with As contaminated ground water, use of high P-fertilizer, use of organic materials, bioremediation of rice culture with algae and making a more oxic condition in the rhizosphere have been tried with varying successes. Selection of the As non-accumulating species of plants seems another possibility.

Sex specific protective effect of hemoglobin on arsenic-induced skin lesions

Carrie V. Breton, E. Andres Houseman, Molly L. Kile, Quazi Quamruzzaman, Mahmuder Rahman, Golam Mahiuddin, **David C. Christiani**[1]

Chronic arsenic poisoning remains a public health crisis in Bangladesh. As arsenic has been shown to bind to human hemoglobin, hematologic mechanisms may play a role in the pathway through which arsenic exerts its toxicity. Two separate studies were conducted to investigate the role of hemoglobin in the development of arsenic-induced skin lesions. Conditional logistic regression was used to investigate the effect of hemoglobin on skin lesions in a study of 900 case-control pairs from Pabna, Bangladesh, in which individuals were matched on sex, age, and location. Mixed linear regression models were used to separately examine the association between toenail arsenic, urinary arsenic, and hemoglobin within a cohort of 184 individuals from 50 families in the same region who did not have arsenic-induced skin lesions. Hemoglobin was significantly associated with skin lesions, but this association was sex-specific. In males a 40% reduction in the odds of skin lesions occurred for every 1 g/dL increase in hemoglobin (OR 0.60; 95% CI 0.49 - 0.73). No effect was observed for females (OR 1.16; 95%CI 0.92 - 1.46). In the cohort of 184 individuals, no associations between toenail arsenic or urinary arsenic species and hemoglobin levels were observed. Low hemoglobin levels may exacerbate the detrimental health effects of chronic arsenic poisoning. While providing clean water remains the optimal solution to Bangladesh's problem of arsenic poisoning, improving nutrition and reducing iron-deficiency anemia may ameliorate negative health effects such as skin lesions in individuals who have been exposed.

Management of Arsenicosis

Dr. Md. Shahidullah Sikder

750 cases of clinically diagnosed arsenicosis patients with cutaneous and systemic manifestation from different parts of the country have been reported for treatment in the Department of Dermatology, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, Bangladesh. Thorough clinical examination and relevant investigation including skin histopathology, USG of HBS, liver function test, kidney function test & estimation of arsenic level in hair have been carried out. 100% patient presented with pigmentary changes in skin, 80% cases found with hyperkeratosis, 20% cases found with cramp in legs, 12% with conjunctival congestion, 2.4% cases were found with hepatomegaly. Estimated arsenic level in hair ranges from 4.86 mg/kg to 52.7 mg/kg. Alkaline phosphatase were raised in 20% cases. Skin histopathology showed hyperkeratosis and melanosis commonly. Along with avoidance of drinking arsenic contaminated water different regimen of treatment have been applied like : (i) Topical use of salicylic acid (5% to 30%). (ii) Systemic oral use of vitamin ACE, (iii) Oral use of spirulina with other nutritional supplement (iv) Cryotherapy for hyper keratosis, (v) Combination of topical application of salicylic acid with oral vitamin & other nutritional supplement. It has been observed that combination therapy is more beneficial but no treatment regimen is curative.

DECLARATIONS OF IN'TERNATIONAL CONFERENCES ORGANIZED BY DCH & SOES

Dhaka Declarations

Declaration of Participants of the International Conference on Arsenic Contamination of Ground Water: Cause, Effects and Remedies, Held in Dhaka, Bangladesh
February 8 to 12, 1998
HENCE FORTH TO BE CALLED:

THE FIRST DHAKA DECLARATION.
Date: February 12 1998

We, the participants from different countries, working of different aspects of the arsenic problem, having visited one of the arsenic affected villages of Bangladesh and having observed the villagers in their natural habitat, the arsenic contaminated tube-wells, the plight of the arsenic affected patients, their suffering and that of their relatives and having listed to the deliberation and the discussions at tit conference, especially of those from Bangladesh, have come to the understanding that:

- The groundwater of a significantly large area in Bangladesh is contaminated with high concentration of arsenic;
- The cause of this arsenic contamination is geological;
- A large number of people including children are suffering from chronic arsenic poisoning;
- The arsenic problem is a threat to public health and the social structure of Bangladesh;
- Supply of arsenic free water is the only solution;
- This could also happen in other parts of world; and
- Coordinated and concerted efforts are needed from National and International organizations and individuals to overcome this severe problem.

We, the participants of this International Conference in Dhaka, do hereby declare that:

- The arsenic contamination of groundwater in Bangladesh needs to be addressed on an emergency basis;
- We shall direct our research for the benefit of all people;
- We shall use our knowledge and expertise and unite resources available to us to determine appropriate community based, affordable and sustainable water supply solution;
- We shall work in a concerted manner to protect and save people from the arsenic problem, ensure treatment of all patients and identify those at risk;
- We agree to share information amongst ourselves, make our findings freely accessible.. and allow others to use them for the interest of all people;'
- We shall assist in the setting up of organizations! canters for research, training, storage and dissemination and allover the world.

ARSENIC PROBLEM AND WATER RESOURCE MANAGEMENT IN BANGLADESH

Held in Dhaka on December 15 1998

THE SECOND DHAKA DECLARATION

Date: December 15, 1998

Following from the International Arsenic Conference, in which those suffering from arsenic participated 10 months ago in February 1998 in Dhaka, the participants in this International

Conference now re-iterates that the arsenic problem is extremely serious and urgent actions are required,

We the participants of the workshop declare that:

a. There is an urgent need to accelerate both the identification of safe 'Water sources and the expansion of mitigation programmes in the affected areas because thousands of people- are suffering and millions of people are consuming arsenic contaminated water and food.

b. All concerned, that is the Government and non Government organizations, local government institutions (Gram and union parishad and municipalities) the World Bank, the development partners and UN bodies, should work together and share all information, knowledge and resources in-order to have a sustainable, affordable and integrated programme because people have been, and continue to suffer.

c. In-order to achieve the successful model for mitigation, communities must be informed and asked to participate in developing appropriate strategies, and in the long run they-must get control of the program.

d. The participation of communities implementing-various mitigation alternatives is essential for developing a sustainable and affordable mitigation program. So communities must decide and chose the strategies and models, which are appropriate to their context.

e. Because the dimension of the arsenic problem has grown beyond drinking water, urgent research work is required to understand the food chain arsenic problem and to determine whether it is important. We call upon government and non-government organizations, the World Bank and other development partners to support scientific programs, in order to achieve proper understanding and in-order to give direction to mitigation programs for this food chain hazard,

f. All information obtained by various workers in Bangladesh and also by workers in other countries should be systematically arranged and stored for quick dissemination of this information. Such information center should build urgently and regularly up-dated to help individuals, groups and communities afflicted to get quick access to knowledge and information on arsenic contamination.

g. The media should call upon government to allocate special programs on radio and TV and also request the private media to participate in mass awareness-building efforts in support of arsenic mitigation.

3RD INTEMATLONAL ARSENIC CONFERENCE HELD AT DHAKA

Held in Dhaka on May 13 & 14,2000

NEED FOR ACTIONS:

We, the participants from different countries and organizations, working on different aspects of the arsenic problem, having participated in the previous conferences, and having listened to the presentation and discussion at this conference, specially of those from Bangladesh, have come to the understanding that:

- A major portion of Bangladesh's groundwater is contaminated with high concentrations of arsenic;
- A large number of people, including children and women, continue to suffer from chronic arsenic poising and more are expected to suffer in the future;
- The arsenic problem remains a major threat to public health and the social structure of Bangladesh;
- Supply of arsenic free, safe water is the immediate need;
- Coordinated and concerted efforts are needed from Government, NGOs the private sector, national and international organizations and individuals to overcome this severe problem;
- On-going efforts need to be accelerate to become effective; and
- Attention also needs to be focused on other related issues, such as arsenic in food and soil.

We, the participants of this International Conference in Dhaka, observe that the progress in dealing with the arsenic problem in Bangladesh has been tragically slow, and do hereby declare that:

- The arsenic contamination crisis in Bangladesh must be dealt with on an emergency basis;
- The entire nation needs to be mobilize to combat the problem;
- Research is needed to in the context of developing a vision for a comprehensive water policy;
- Attention must be given to the needs of the arsenic patien1s and their management; and
- All agencies, whether government, non-government, donor, academic, national or international, must act now. There is no time to waste - enough knowledge is available to undertake the basic steps - to stop people from drinking arsenic contaminated water through social mobilization and involvement of villagers and local government bodies in the screening and mitigation activities, tapping into the indigenous knowledge of the villagers themselves and validating it through scientific methods.

Act immediately! Remember. a day lost is a few lives lost!

ARSENIC CONTAMINATION OF GROUND WATER: CAUSES, EFFECTS AND REMEDIES

Held in Dhaka on January 12 & 13,2002
Henceforth to be called

THE 4TH DHAKA DECLARATION

13th January 2002

It is with profound distress that we, the Participants of the 4th International Arsenic Conference, have noted that no significant achievement been reached so far regarding the supply of arsenic free safe water to the people of Bangladesh. We were, however, pleased to note that major initiatives are being started. But considering the severity and magnitude of this enormous human tragedy, the efforts are still too slow. As such, we urge upon all concerned. Irrespective of their nationality or affiliation. to come forth to help the people of Bangladesh on an emergency basis.

We have heard and noted the progress achieved in mitigating the arsenic crisis from the 1st International Conference in 1998. While we appreciate that efforts are more significant than in the previous years, we cannot but stress the need for placing greater emphasis on the formulation of a framework of a National Strategy for arsenic mitigation. **In** this strategy, the interests of the people of Bangladesh would be given utmost priority.

More specifically, we the Participants do hereby declare that:

In matters relating to patient management

There is no known treatment for arsenic skin lesions.

It is important to develop both an acceptable treatment and management protocol for the numerous patients suffering from arsenic skin problem.

Disease caused by chronic arsenic poisoning and its complications need to be properly defined. A widely acceptable protocol should be developed and implemented by the health system for patient management.

In matters relating to water resource management

Extreme caution must be exercised before recommending any solution, either as an alternate source or as a form of arsenic removal technology unless a competent authority carries out adequate scientific evaluation.

Bangladesh being endowed with abundant surface water and rainwater, all agencies must consider the use of surface and rainwater before suggestion ground water withdrawal except in unavoidable circumstances or in safe areas.

Before recommending extraction of ground water from deeper aquifers, the safety of the

deep aquifers must be ensured and adequate understanding of the geological parameters developed to ensure that these aquifers would not become contaminated in the future.

More understanding is required to quantify the impact of arsenic contaminated irrigation water on the food chain and food production.

As alternate water sources are being identified, extraction of ground water from shallow aquifers should be banned except in safe areas or in unavoidable circumstances.

We, the Participants of this Conference, Recommend

All activities related to arsenic mitigation or research in Bangladesh should be significantly increased and expedited after scientific evaluation.

All mitigation activities must be undertaken to ensure the full participation of local communities and local government institutions before during and after implementation to ensure the ultimate ownership. We believe that without the involvement of communities and local government institutions all efforts will be unsustainable.

All future mitigation activities should involve the private sector, forging a partnership and coordination between the public and private institutions.

In conclusion, we re-iterate the seriousness of the situation in Bangladesh and urge all concerned to actively assist the people of Bangladesh in overcoming this mega crisis.

5th International Conference on Arsenic
Developing Country's Perspective on Health, Water and Environmental Issues

Held in Dhaka on February 15th , 16th & 17th , 2004
Henceforth to be called
The 5th Dhaka Declaration
Date: 15.02.04

We, the Participants of the 5th International Arsenic Conference, note that while certain achievements been reached so far regarding the supply of arsenic free safe water to the people of Bangladesh, concrete and long-lasting efforts remain to be implemented. We were, however, pleased to note that a national policy and guidelines is under the process of approval by the Government of Bangladesh regarding the supply of safe drinking water to the arsenic affected population. We understand that major initiatives have started. but considering the severity and magnitude of this human tragedy, the efforts are still too slow. As such. We continue to urge upon all concerned, irrespective of their nationality or affiliation, to come forth to help the people of Bangladesh on an emergency basis.

We have heard and noted the progress achieved in mitigating the arsenic crisis from the 1st International Conference in 1998 till the 4th Conference in 2002. While we appreciate that efforts are more significant than in the previous years, we cannot but stress the need for placing greater emphasis on patient care and development of an approved protocol for the treatment of arsenic patients. In this strategy, the interests of the people of Bangladesh should be given utmost priority.

More specifically, we the Participants do hereby declare that:

In matters relating to patient management, It is important to develop both an acceptable and affordable form of treatment, keeping in mind that many of the patients will not be able to afford costlier forms of management.

In matters relating to water resource management, all stakeholders are earnestly requested to adhere to the National Arsenic Mitigation Policy and the Implementation Plan under the process of approval by the Government of Bangladesh. As mentioned in the Policy, priority must be given to exploiting perennial sources of surface water, which is found in abundance in Bangladesh. Bangladesh being endowed with abundant surface water and rain water, all agencies must consider the use of surface and rain water before any suggestion of ground water withdrawal is made, except in unavoidable circumstances
or in known safe areas.

Before recommending extraction of ground water from deeper aquifers, the safety of the deep aquifers must be ensured and adequate understanding of the geological parameters developed to ensure that these aquifers would not become contaminated in the future.

3rd party audit and analysis of all the deep tube-well both Government and Non-Government installed from 1997 onward should be undertaken immediately to monitor the quality. This has become very urgent from the experience of the Sharsha Upazila
More understanding is required to quantify the impact of arsenic contaminated irrigation water on the food chain and food production.

We, the Participants of this Conference, Recommend that:

All activities related to arsenic mitigation or research in Bangladesh should be significantly increased and expedited after scientific evaluation.

All mitigation activities must be undertaken to ensure the full participation of local communities and local government institutions before, during and after implementation to ensure ultimate ownership. We believe that without the involvement of communities and local government institutions all efforts will be unsustainable. Transparency and mutual respect should the basis for all future work.

All future mitigation activities should involve the private sector, forging a partnership and coordination between the public and private institutions.

Tests so far indicate that none of arsenic removal technologies works in all the hydrological regions. It is strongly recommended that more scientific scrutiny and public discussion should be held before validating any of the technologies for the purpose of marketing and large-scale use.

In conclusion, we re-iterate the seriousness of the situation in Bangladesh and urge all concerned to actively assist the people of Bangladesh in overcoming this crisis.

6th International Conference on

"Safe Water and Safe Food Options in Arsenic Mitigation: Lesson Learnt"

Dhaka Declaration

1. Over hundred researchers and professionals from home (Bangladesh) and abroad (Australia, India, U.S.A.), gathered at the 6th International Conference on Arsenic express concern that, though some progress has been made to contain arsenic contamination and mitigate its adverse impacts including treatment of affected patients, we are yet to take up the subject with the seriousness and deligance it demands.

2. The participants taking note that the aim of this conference is to look back over the last 10 years and learn from the accumulated knowledge from the successes and failures, advantages and disadvantages of mitigation options, and also from various action programmes and mitigation strategies carried out by agencies and organizations in the arsenic contamination areas calls for a development and implementation of a coordinate programme.

3. Apprehending that Arsenic in drinking water could turn out to be a “Slow weapon of Mass destruction”, we urge upon the media to high light the threat of Arsenicosis and sensitize all concerned to adopt measures to fight threat.

4. Being aware that there is no known cure for Arsenicosis, the disorder from Chronic Arsenic poisoning, we call for ensuring supply of safe drinking water in all arsenic affected areas.

5. Noting that deeper aquifer may be contaminated by vertical movement of water, we urge upon concerned authorities to monitor installation of all tube wells so that proper depth is achieved and the tube wells are properly sealed.

6. Concerned that tube wells are being installed with out proper quality control, we call for independent third party evaluation of all deep tube wells.

7. Realizing that irrigation water containing arsenic affects soil and crops and thus enter the food chain, indicated by some research outputs, we call for further research activities to establish the relationship between arsenic in irrigation water and its accumulation in crops.

8. Recognizing that rain water harvesting would be a viable option for safe drinking water, we urge upon all concerned to maximize its use.

9. Noting that various relevant policies give preference to surface water, we would expect all agencies concerned to maximize utilization of surface water.

10. And finally we the participants being aware that the National Arsenic Mitigation policy and its Implementation plan needs to be taken down to local Community level for getting proper response to the problem.