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on

Arsenic Contamination of Ground Water in Bangladesh: Cause, Effect and Remedy

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Dhaka Community Hospital
190/1 Baro Maghbazar, Wireless Railgate
Dhaka-1217, Bangladesh
Tel: (+88-02) 9351190-91, 8314887
Fax: (+88-02) 9338706
Email: dch@bangla.net
Website: www.dchtrust.org

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Editors

Prof. Quazi Quamruzzaman

Prof. Mahmuder Rahman

Alison Quazi

Qazi Habibur Rahman

Ranajit Das

Jabed Yousuf

Ranak Chandra Mohanta

A.E. Sohel

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PREFACE

The Fourth International Conference on Arsenic Contamination of Groundwater in Bangladesh: Cause, Effect and Remedy was held in Dhaka on 12-13 January, 2002. The conference was organized to share and disseminate the experiences of all those working globally to combat the problems caused by arsenic contamination and the implications for Bangladesh. Arranged by Dhaka Community Hospital and the School of Environmental Studies, Jadavpur University, Kolkata, India, it resulted in the 4th Dhaka Declaration, which remarked the slow progress of mitigation for the people of Bangladesh but acknowledged the efforts being made.

Although not mutually exclusive the conference topics dealt with arsenic in groundwater; consequences for food production and consumption; the effects on health; intervention strategies and policy implications.

The papers looking at groundwater contamination continue to expand understanding of the problem and provide information about the longer-term aspects of the problem, solutions and policy implications. Research into water resource management and projection of future requirements is of major importance to all affected countries.

The effects of arsenic contamination in agricultural production, particularly irrigation, has not been subject to as much study as the direct consumption of contaminated water but preliminary findings are reported and further research is being designed and undertaken.

The effects of chronic arsenic poisoning on human beings are described and the papers report on epidemiological aspects, diagnosis and clinical findings and suggested treatments.

Intervention strategies in the field, experiences and results were presented and discussed. These focused mainly on water mitigation rather than on patient identification and management. It was encouraging to note the number of strategies that were exploiting the natural abundance of surface water for alternative water supply within Bangladesh and West Bengal.

A small number of papers dealt specifically with policy implications, looking at responsibilities for the problem and how it can be managed on such a large scale but all the papers that were presented at the conference and the discussions that followed are valuable documents for use in planning subsequent intervention strategies in the battle against the arsenic crisis.

Professor Quazi Quamruzzaman
Chairman
Dhaka Community Hospital Trust

ACKNOWLEDGEMENTS

We should like to record out thanks to Dr. Dipankar Chakraborti of the School of Environmental Studies, Jadavpur University, Kolkata, for his ceaseless work and efforts to expose the arsenic problem of Bangladesh.

We thank the sponsors for their readiness to help with funding the conference: Aventis, Concord Group of Companies, Duncan Brothers Bangladesh, Eskayef of Bangladesh Ltd, Renata Ltd, Singer Bangladesh, Square Pharmaceuticals Ltd and Transcom.

We thank the special guests who so willingly gave their time to address the meeting: Justice S M Afzal, ex-Chief Justice Supreme Court of Bangladesh who opened the proceedings, AYBI Siddiqui, Secretary, Ministry of LGRD and Local Government; Sabihuddin Ahmed, Secretary, Ministry of Forest and Environment; Mahafuz Anam, Editor, The Daily Star, Mahbub Jamil, Managing Director, Singer, Bangladesh and Tapan Chowdhury, Managing Director, Square Pharmaceuticals Ltd. and President of the Metropolitan Chamber of Commerce.

We also thank Mr. Md. Mustafizur Rahman, Executive Engineer and Focal Person, Community Based Water Supply and Sanitation Project of the DPHE for his help and co-operation, BIAM management, the organizers, advisors and friends who worked hard to make the conference a success, not forgetting all the participants.

Our special thanks go to Professor AQM Badruddoza Chowdhury, Honourable President of the People's Republic of Bangladesh, who, despite his heavy schedule, addressed the Conference as the Chief Guest at the closing session.

THE 4TH INTERNATIONAL CONFERENCE
ON
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

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 adequate scientific evaluation is carried out by a competent authority.

Bangladesh being endowed with abundant surface water and rain water, all agencies must consider the use of surface and rain water 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 will 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.

LESS WORDS AND MORE DEEDS, PLEASE

Address by the Chief Guest:
Prof. A.Q.M. Badruddoza Chowdhury
Honourable President of the People's Republic of Bangladesh

Given at the at the Closing Session

Bismillahhir Rahmanir Rahim,
Mr. Chairman, Scientists, Participants. Ladies and Gentlemen, Assalam-o-alaikum.

Bangladesh has a network of hundreds of rivers and tributaries and thousands of ponds, wells and other water bodies. Before the introduction of tube-wells, people did use surface water, the sources being rivers, canals, lakes, and manmade water reservoirs, like dug-wells but the surface water in Bangladesh is mostly contaminated, not with arsenic but water borne diseases. Then the countrywide program of installing tube-wells came in. Tube-wells of course are free from water borne diseases and this did prevent diarrhoeal diseases. Now they are a source of causing the massive problem of arsenic contamination throughout the country. It is estimated that out of 140 million inhabitants of Bangladesh probably 70 million are at present, or will be in the future, affected by arsenic poisoning. This is a huge health problem and the largest environmental catastrophe now happening in this part of the world. Out of 64 districts probably 61 districts have contaminated tube-wells with high levels of arsenic. WHO has set a guideline for measuring the value of arsenic contaminated drinking water as 0.01 mg/l as safe, although in Bangladesh we have adopted a level of 0.05mg/l arsenic in water. A similar condition is found in West-Bengal.

Ladies and gentlemen, Dhaka Community Hospital played an important role in advocating safe water options in collaboration with Jadavpur University, Kolkata, West Bengal, India. It organized the first international seminar in 1998 and has held 4 seminars on the subject. How much have we progressed practically?

Millions of people suffer from chronic arsenic poisoning not only in Bangladesh but also in many countries of the world. We need research in the field of chronic arsenic poisoning directed to understand arsenic related disorders and to understand the long-term effect of arsenic poisoning in the human body. Probably it will take 10 to 20 years for the ill effects of arsenic in the human body to surface. There is a further scope of research regarding effect of arsenic on reproductive health. Proper investigation is urgently required to address the issue of food and medicine contamination with arsenic. For understanding and addressing the crisis, therefore it is necessary to have an integrated policy, which is affordable and easily accessible.

The Government of Bangladesh along with other agencies like Dhaka Community Hospital, NGOs, Rotarians, Lions, other donor agencies, should come forward to help and guide the community to implement long-term mitigation programs. We welcome institutions that carry out research to find suitable treatment and management for the thousands of people who are suffering and these should be given all possible help and cooperation.

We should look carefully around us. Bangladesh is the second or third country in the whole world regarding the availability of surface water, which is a big thing. It is a gift from nature. The surface water is arsenic free and can be utilized by using low cost treatment technology. We need research on this and scientists must come up with findings so that surface water may be number one option for arsenic free drinking water.

Number two; there are few countries in the world where it rains nearly 7 or 8 months a year. Rainwater is not only arsenic free, it is also disease free. We can conserve the rainwater in such a way so that it can be used 6 to 8 months in a year. We ought to collect rainwater and ask people to drink rainwater. A simple formula may be introduced using a rain-catching polythene sheet of 10 feet by 10 -15 feet. Rainwater can be collected for future use in a 'Motki' or a big vessel. A 10 by 10 feet polythene sheet will be enough for a modest size family for drinking purposes. It is very cheap, affordable, sterile and arsenic free. A recent paper on arsenic published from the ICDDR,B states that straining pond water/surface water through several layers of clean cloth 6 - 8 yards folded, cleans up bacteria by more than 90% and using alum (fitkiri), raises the figure to the level of 99%. These are not highly expensive methods. These are not unknown to the people, only they have been forgotten because of their tube-well habit over the last 50/60 years.

Can I draw your attention to other issues? There are many problems in this country. One is arsenic. Second is ‘B’ hepatitis, which is killing literally thousands of people every year due to cirrhosis of the liver. This can be prevented by a program of ‘B’ hepatitis immunization. The third problem is HIV infection. These three health problems, Arsenic, ‘B’ hepatitis and HIV together will not only cripple but destroy the social, political and economic prospects of a country like Bangladesh in the near future. The Government has taken note of the three problems and already three national committees have been formed which will be announced very soon: on arsenic mitigation, on ‘B’ hepatitis prevention and on HIV. My name has been proposed as a patron and I hope to be an active patron and not a sleeping partner.

Ladies and gentlemen, with these words I should like to thank you all and I am certain you had very fruitful and pragmatic deliberations followed by conclusions which I think are practical and effective.

Thank you all once again, Allah Hafez. Bangladesh Zindabad.

IN-SITU REMEDIATION OF ARSENIC IN GROUND WATER

Alan H. Welch[1] and Kenneth G. Stollenwerk[2]

Introduction:

Remediation of arsenic in ground water has received increased attention in the United States because of the costs that may be required to comply with a lowered drinking water standard, which was 50 ppb from 1942-2000. Removal of arsenic from ground water within an aquifer, or in-situ remediation, can result in significant cost benefits compared with above ground treatment. Lower costs may be realized because of lower capital and operating costs, a simpler and less-expensive operation, and avoidance of sludge and wastewater disposal (Rott and Friedle 1999).

Design of in-situ remediation requires an understanding of both the geochemistry and hydrology of a ground water system. Based on this understanding, modification of the chemistry of ground water or aquifer materials may be possible in a manner that results in arsenic removal from ground water. Additionally, ground water with high arsenic concentrations flowing into an aquifer with different geochemical characteristics may result in arsenic removal. Accordingly, arsenic removal may be promoted by pumping that results in flow into aquifers with a chemistry that promotes arsenic removal.

Discussion:

In-situ removal has been successful in decreasing arsenic concentrations from ground water containing high concentrations of both arsenic and iron. Pumping water from one well into a second well after adding atmospheric oxygen can result in arsenic removal from the ground water (Rott and Friedle 1999). The recharged well can then be used for water supply. One advantage of this approach is that 10 or more gallons of low-arsenic water can be obtained for each gallon recharged. Additionally, removal efficiency increases with successive cycles of recharge and withdrawal.

HFO (hydrous ferric oxide) appears to be the most important phase responsible for removing the arsenic from the ground water (Appelo and de Vet in preparation). The arsenic removal process associated with iron removal may be described as a series of reactions involving dissolved oxygen, aqueous and exchangeable Fe and other cations, and arsenic. Injection of water containing dissolved oxygen can lead to rapid exchange of Fe^{2+} for cations in the injected water with subsequent Fe^{2+} oxidation to form HFO. Upon reversing the flow direction, the injected water has a lower iron concentration. Continued pumping can produce water with a lower iron concentration because Fe^{2+} is removed by exchange. Arsenic can co-precipitate with the HFO during injection and adsorption onto the HFO during withdrawal.

A second approach that can lead to arsenic removal is lowering of pH where alkaline ground water contains high arsenic concentrations (Welch, Stollenwerk et al. 2000; Welch, Stollenwerk et al. in preparation). In the system studied, ground water had a high pH (about 9.2) and contained >100 ppb arsenic. The HFO content of the aquifer was increased through the injection of $FeCl_3$ followed by injection of oxic ground water with a lower pH.

Areas of needed research:

Although the effect of some competing anions, such as P, on the efficiency of arsenic removal is well established, the effect of anions such as CO_3^{2-} is less certain. Additionally, the effect of multiple anions typically found in ground water, such as sulfate, phosphate, and silica under varying pH conditions is not adequately understood.

Altering a hydrologic regime to promote arsenic removal in systems like those found in some parts of the Bengal Delta might be possible. In some parts of the delta, sediments containing iron oxide underlie more reduced sediments containing high arsenic ground water (Foster, Breit et al. 2000). Pumping of the deeper aquifer could bring shallower, high arsenic ground into contact with iron oxide in the deeper aquifer, possibly leading to arsenic removal. This approach may be possible, although considerable research is needed to evaluate the long-term viability of this approach and to identify those parts of the delta where arsenic removal could occur.

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U.S. Geological Survey, [1]Carson City, NV, E-mail: ahwelch@usgs.gov, [2]Lakewood, CO kgstolle@usgs.gov

SPECIATION OF ARSENIC IN SEDIMENT LEACHATE BY CHROMATOGRAPHIC SEPARATION AND FLOW INJECTION HYDRIDE GENERATION ATOMIC ABSORPTION SPECTROMETRY

D. Chowdhury[1], M. Bhattacharya[1], H. Bibi[1], S. Begum[1], M. S. Islam[1], M. Alauddin[2], M. Fiasconaro[2], A. Hussam[3], A.M. Sikder[4],

Analysis of a set of bore-hole sediments from Itchapur village in Comilla, at depths ranging from 5 to 90 feet, revealed presence of high levels of arsenic. The groundwater samples from the same village also contained elevated levels of arsenic. Bacteria and microorganisms in soils and sediments can transform inorganic arsenic to methylated species, namely, monomethylarsonate (MMA) and dimethylarsonate (DMA). The methylated arsenic species are relatively less toxic than inorganic arsenic. The speciation of methylated arsenic in sediments and groundwater is essential to assess arsenic exposure and health risks from consumption of well water and crops grown in surface soil.

We have developed a technique for separating and analysis of various arsenic species, such as, arsenite, arsenate, monomethylarsonate (MMA) and dimethylarsonate (DMA) in sediment leachate and groundwater collected from the same area. The technique is based on chromatographic separation followed by flow injection hydride generation atomic absorption spectrometry (FI-HG-AAS). Arsenite was found to be a major component and lower levels of MMA (6 to 61 ppb) and DMA (5 to 19 ppb) were detected in these samples. The detection limit varies from 1.0 – 2.0 ppb for various species. The speciation of inorganic and methylated arsenic has been carried out at the Intronics Technology Center, Dhaka. To the best of our knowledge, this is the first such study by a local research organization in Bangladesh. Preliminary results from our findings and future application of the methodologies will be discussed.

[1]Intronics Technology Center, Dhaka, Bangladesh
[2]Wagner College, New York, USA
[3]George Mason University, Virginia, USA
[4]Arsenic Research Group, Dhaka, Bangladesh

EMPIRICAL FIELD STUDY ON VARIATION OF ARSENIC IN HANDPUMP TUBEWELLS DURING OPERATION OF IRRIGATION WELLS

Disaster Forum

Arsenic is considered to be associated with buried sediments and under reducing condition it is released into groundwater. Prior to 1970 when millions of people were drinking tube-well water for decades from more than 200,000 hand-pump tube-wells, there was no known arsenic related problem. This implies, though arsenic was in ground water, its entry into hand-pump tube-wells was insignificant. But after liberation in 1971, large scale installation of hand-pump tube-wells both in public and private sector began. Today there are about 4 million hand-pump tube-wells in the country. Though this figure is appalling, it is believed that these wells do not significantly influence groundwater movement, hence no or limited role in entry of arsenic into themselves. The other most significant development that took place since liberation was ground water based irrigation to boost food production. The growth of irrigation wells between early 1970s and late 1990s has been revolutionary. The number of irrigation tube-wells grew from few hundreds to about 800,000 during this period. These wells operate round the clock during dry season (January - June) abstracting water at a high rate accelerating ground water movement. It is believed that this accelerated movement of groundwater is one of the causes of entry of arsenic into hand-pump tube-wells. To test this hypothesis the subject study in an existing field situation in Niltek village, Singair, was undertaken. The study area consists of two irrigation wells surrounded by 8 hand-pump tube-wells. Arsenic was measured monthly from each well during January to November 2001 to note the variation over the period. At the same time, daily operating times of the irrigation wells were recorded. No other data such as water level, bore log, soil analysis etc were collected. But depths and distances of the hand pump tube-wells from the irrigation wells were measured. The study is being financed by UNICEF. The final report is under preparation.

The most significant finding of the study is that considerable variation of arsenic in each well was observed, often exceeding safe limit, during the entire period under study with peaks during dry season as well as wet season. Towards the end of dry season when the irrigation wells also were at the fag end of operation, the arsenic concentrations in hand-pump tube-wells were independent of their horizontal distances from the irrigation wells implying no relationship with the horizontal movement of ground water. But some inverse correlation between the depths of the hand-pump tube-wells and arsenic concentration has been observed. This implies significance of vertical component of the ground water flow transporting arsenic vertically down from the upper layer of soil, which is believed to be the main source of arsenic under ground. WHO in its guideline stated that average content of arsenic in earth crust is 2 mg/kg. In Samta village, South Western Bangladesh, the upper layer of soil contains from 0.7 to 23.0 mg/kg of arsenic rising as high as 46.5 to 261.5 mg/kg in peaty samples. In the wet season also when irrigation wells were not operative, higher arsenic concentration was observed in the hand-pump tube-wells. This is probably caused by mixing of groundwater with upper soil due to rise of water level in wet season. These findings except the observed variation in arsenic concentration are only presumptive to be studied further more scientifically for confirmation.

MONITORING AND WATER QUALITY: AN OVERVIEW AND RECOMMENDATION

Sharmeen Murshid[1], MK Mustafa Anowar[2], Mala Khan[2]

The history of drinking water in Bangladesh shows a systematic lack of water monitoring and absence of a water quality control system that has had far reaching consequences in Bangladesh. The authors here contend that this non-monitoring of water quality is the main reason for the drinking water crisis in Bangladesh. First part of this paper traces the missed opportunities to monitor drinking water quality within some of the major water initiatives in the country, which could have contained the crisis. It also criticizes the premises and some of the data and statistics produced that presently guide water policies and decisions in the country. It notes some of the inconsistencies in application of statistics; use of undefined terminologies and questionable interpretation of data hence leading to conclusions that misguide policies and encourage the rash adoption of technology. It is eight years now since the first alarm bells rang yet Bangladesh is still struggling with basic data. In order to assume a holistic approach of water quality and quantity management, water quality monitoring must be within the basic structure of policy decisions and management priorities. For an effective monitoring program several principal components are discussed including a detailed and defined plan for quality control and quality assurance, as analytical data without reliability and traceability are only garbage.

Strict adherence to Standard Operating Procedures (SOP) and Total Quality Management (TQM) at all stages from sampling to reporting are integral parts of Quality Monitoring Programs. A short overview on the Analytical Data QC/QA system is discussed. Contrary to popular belief, this two year study proves beyond doubt that Bangladesh has the capability for water quality monitoring and analysis that can be internationally accepted. Lapses of the past must be rectified through a transparent and accountable system of water quality control management system under the guidance of a strict government regulatory body.

Brotee initiated a two year study with Plasma Plus Application Laboratory. This paper has been jointly prepared.

[1]Brotee - A Commitment to participation: 83 Laboratory Road, KJH Mansion (2nd Floor), Dhaka-1205, Tel: 9669288, 8625121, Fax: 9880790, 9669288, E-mail: brotee @bdmail.net
[2]Plasma Plus Application and Research laboratory, House No. 48/6, Road 9A on Sat Masjid Road, Dhanmondi, Dhaka-1209. Tel: 9112492, 9122407& 9112290, Fax: 9880790, 9112243, E-mail: plasma@bdcom.com

THE IMPACT OF THE ARSENIC CRISIS ON AGRICULTURE

Richard Loeppert

Arsenic impacts agriculture in several ways. Arsenic is toxic to plants, as it is to animals, as a result of its influence on plant biochemical process. In high concentrations, arsenic can result in reductions in crop yield. Several plant physiologic disorders e.g., "straighthead" in rice, can be induced by arsenic. Arsenic can be absorbed to some extent by all plant species. The amount of absorption and translocation to the plant tops is highly variable among plant species, and is also strongly influenced by soil characteristics, soil fertility, and arsenic concentration cause in soil. Arsenic can degradation and loss of agricultural productivity that might occur as a result of increases in soil arsenic by irrigation with arsenic – contaminated water.

Agriculture also directly impacts the arsenic crisis, most notably through its impact on human nutrition, which is probably the major influencing human resistance to arsenic – toxicity. The foundation of good nutrition in Bangladesh is its agricultural product.

The strengths of Bangladesh are in its land, water, agricultural, and human resources. The arsenic crisis in Bangladesh represents significant new challenges to the agricultural community, specifically as related to irrigation management, soil and crop management, crop selection, agricultural diversity, and nutrition.

Texas A & M University, USA

ARSENIC CONTENT OF RICE IN BANGLADESH AND IMPACTS ON RICE PRODUCTIVITY

J.M. Duxbury[1], A. B. Mayer[2], J.G. Lauren[1] and N. Hassan[3]

The concentration of total arsenic in 150 samples of rice grain (paddy) collected from Barisal, Comilla, Dinajpur, Rajshahi and Rangpur districts in Bangladesh ranged from 10 to 415 µg/kg dry weight. Both crop yields and grain arsenic concentrations were higher for boro (winter season) rice compared to aman (monsoon season) rice, as would be expected from greater use of groundwater for irrigation in the boro season. Mean values were 183±101 (n=78) and 117±48 (n=72) µg/kg dry weight for boro and aman season samples, respectively. The highest arsenic values were found in rice from Barisal and Rajshahi districts and, with the exception of Comilla, matched maps of groundwater arsenic concentrations reasonably well. No trends were observed between the concentration of arsenic in grain and either crop yield or panicle sterility, suggesting that arsenic was not toxic to rice at the levels observed in the grain. The data set represented 39 different rice varieties and was inadequate to evaluate variety differences in arsenic uptake. Geographic location, as a surrogate for levels of arsenic in irrigation water, was most likely the factor controlling arsenic uptake by rice in this data set.

The combination of parboiling and milling of rice significantly reduced ($p<0.0001$) grain arsenic levels by an average of 17% from 155 to 125 µg/kg dry weight (n = 21). This fairly small change suggests that processing of rice will not substantially reduce exposure to arsenic from this source.

Soil samples corresponding to the rice grain samples are being processed for arsenic analysis and a complete mineral analysis of rice grain will also be undertaken.

Agricultural management strategies to reduce the risk of arsenic phytotoxicity to rice and uptake of arsenic into rice grain are discussed.

[1]Department of Crop and Soil Sciences, Bradfield Hall, Cornell University, Ithaca, New York 14853, USA
e-mail: jmd17@cornell.edu
[2]Division of Nutrition, Savage Hall, Cornell University, Ithaca, New York 14853
[3]Department of Nutrition, Dhaka University, Dhaka, Bangladesh

ARSENIC IN FOOD CHAIN

S.M. Imamul Huq[1], Nazma Sultana[1], Ray Correll[2], Ravi Naidu[2]

Arsenic contamination of ground water in Bangladesh and the incidence of arsenicosis patients do not go hand in hand. People living in the same household and drinking from the same source of arsenic-affected water are not equally affected. Moreover, the manifestation of arsenicosis also varies from region to region in the country. This has raised the question about the sole contribution of arsenic-contaminated drinking water as to the cause of arsenicosis. Much effort has been directed towards ensuring supply of arsenic-free drinking water with varying successes. Even if arsenic-safe drinking water is assured, the question of irrigating soils with arsenic-laden ground water will continue for years to come. The possibility of arsenic accumulation in soils through irrigation water and its subsequent entry into the food chain through various food materials cannot be overlooked. With this view in mind, more than 1000 water, soil and vegetables samples collected from arsenic affected area as well as from unaffected areas have been analyzed for arsenic in them. Other sources of foods have also been analyzed. Comparison of the results form affected and unaffected areas reveals that many of the commonly grown vegetables, otherwise suitable as good sources of nourishment, accumulate substantially elevated amount of the element in the inorganic form – form toxic than the organic form. Details will be presented in the paper.

[1]Dept. of Soil, Water and Environment, Dhaka University, Dhaka1000
[2]CSIRO, Adelaide Laboratory, Australia.

ARSENIC PAST PRESENT AND FUTURE

RN Ratnaike

Over many centuries arsenic has had a variety of uses ranging from a component of cosmetics, a therapeutic agent by Greek physicians, as late as the twentieth century in Fowler's solution and as a favorite assassins tool. Arsenic is now best known to the public as a weapon used in murder both in fiction and in real life. Unfortunately the lives of many millions of people are threatened due to arsenic contamination of drinking water in Bangladesh. Arsenic contaminated water has the potential to affect people in many other countries though in lesser numbers. Arsenic is used extensively in industry more recently in semiconductor manufacturing, in light emitting diodes, lasers, photo-detectors, and microwave circuits.

The toxicity of arsenic is determined by its valance state, if it is in organic or inorganic form, and the physical properties governing its absorption and elimination. Organic compounds of arsenic are non-toxic whereas inorganic compounds are toxic and trivalent arsenic is sixty times more toxic than pentavalent arsenic. Organic arsenic compounds are taken up actively and rapidly excreted unchanged in the urine. Inorganic compounds undergo hepatic biomethylation to produce less toxic metabolites for excretion. Ingested biological arsenic has a half-life of approximately four days. Arsenic is absorbed by inhalation or through contact with the skin though ingestion and absorption via the gastrointestinal tract is the dominant route. Arsenic absorption, based on animal studies, occurs in the upper small intestine though mechanisms of absorption and modulating factors to increase or decrease absorption are not known.

Arsenic exerts its toxicity by inactivation of many important enzyme systems, especially those involved in cellular energy pathways and DNA synthesis and repair. Arsenic has a particular predilection for binding sulfhydryl groups in tissue proteins of the liver, lungs, kidney, spleen, gastrointestinal mucosa and keratin-rich tissues (i.e. skin, hair and nails). Animal studies have shown that arsenic deficiency may also be detrimental and has been linked with increased mortality, reduced fertility, increased spontaneous abortion rate, low birth weight in offspring and damage to red blood cells.

Normal intake of arsenic is via ingestion of mainly organic forms and ranges from 8 to 104 micrograms (average 50 micrograms) daily. Elevated levels of arsenic can result in both acute and chronic poisoning depending on the dose and duration of exposure. Analyses of blood, urine and hair samples are used to quantify and monitor exposure. Generally, a dose of 120 to 200 milligrams of arsenic would prove lethal in an adult. Levels between 0.1 and 0.5 milligrams per kilogram on a hair sample indicate chronic poisoning whilst 1.0 to 3.0 milligrams per kilogram indicates acute poisoning.

Both acute and chronic arsenic poisoning produce widespread systemic pathology and symptomology. The clinical presentation in acute poisoning includes nausea, vomiting, profuse watery diarrhoea, abdominal pain, excessive salivation and seizures. The ensuing massive fluid loss leads to reduced circulating blood volume and eventual death due to circulatory failure, usually within twenty-four hours to four days following ingestion.

The consequences of chronic arsenic toxicity are pervasive and impinge on almost all organ systems of the human body. The initial symptoms are non-specific such as abdominal pain, diarrhoea and sore throat. There are many skin changes and signs of peripheral vascular and nervous system disease. Arsenic crosses the placenta and high levels have been shown to be teratogenic in animal studies. Of greatest concern is the now well-established consequence of malignant change in numerous organs due to long term exposure to arsenic. Arsenic exposure has been linked to cancers of the skin, lung, liver, kidney and bladder. Arsenic may act as a co-carcinogen, tumour promoter or tumour progressor under certain circumstances. Arsenic is currently being used successfully as an anti-carcinogenic agent in treating acute promyelocytic leukaemia.

What of the future? Much is yet to be clearly understood. Many aspects of arsenic contamination of water, absorption within the gastrointestinal tract, the role of carriers, and mechanisms of toxicity need further study. However the priority in Bangladesh is in initiating urgent measures to provide safe drinking water to those affected. Potable water that is easily accessible and affordable. The web of devastation caused by arsenic toxicity extends beyond the victim. In addition to the incalculable cost of human suffering, the existing economic burdens of the victim and family are compounded by medical costs and loss of productivity that lead to further income loss. Existing problems of under nutrition and sub-optimal health are further worsened. Reduced crop productivity and quality, due to lack of suitable land and water for agriculture is an added burden to the rural poor. These issues are of serious concern in Bangladesh where 97% of the rural population relies on arsenic contaminated water for drinking, cooking and irrigation.

Future considerations need to be both preventive and curative. While many technologies exist for decreasing or eliminating arsenic from drinking water, the costs involved may be prohibitive. It is important that simple common sense solutions are not submerged by more expensive and complicated methodology that would be an economic burden to purchase and an expensive technological burden to maintain. One of Bangladesh's most valuable assets is its massive sources of as yet untapped uncontaminated water that may well provide the lasting solution to the great humanitarian problem confronting the country.

University Of Adelaide, South Australia, Australia

DIAGNOSIS OF ARSENICOSIS

K. C. Saha

Arsenicosis in West Bengal and Bangladesh was discovered by the author in 1982 and 1984 respectively. First step in diagnosis is to know that arsenic is the cause of patient's illness, second step is the mode of arsenic entrance, exogenous (drugs, food, industrial effluents) or endogenous i.e. groundwater through tube-wells. Third step is to know the source, the soil. Fourth step is to know the mechanism of leaching from soil source. Fifth step is to know the reason why some country or selected parts of the country are predisposed to Arsenicosis. Clinical diagnosis of Arsenicosis is made if both melanosis and keratosis are found in adults.

Melanosis and keratosis may be diffuse, spotted or both. Melanosis is the earliest skin sign which slowly develops after prolonged arsenic entrance in body for 6 months to 10 years by drinking arsenic contaminated groundwater above permissible limit 0.05 mg/l (50 μg/l). The author classified Arsenicosis into 4 stages, 7 grades and 20 sub-grades. The 4 stages are (I) preclinical (II) clinical (III) Complications and (IV) Malignancy. Preclinical period depends on (a) arsenic concentration in consumed water, (b) volume of daily-consumed water and (c) malnutritional status. Malignancy does not develop before 10 years from the onset of clinical signs of toxicity. Melanosis or keratosis found in newborn or children below 5 years is not due to Arsenicosis. Both under diagnosis and over diagnosis of Arsenicosis are to be avoided. In suspected case, high arsenic level in nails (> 1 mg/kg), hair (>1 mg/kg), skin lesions, urine (>40 μg/day) and consumed water (> 50 μg/l), confirms the diagnosis of Arsenicosis. Instead diffuse melanosis may be from Sun exposure, Addisson's disease, haemochromatosis, Shamberg's disease and many others. Instead spotted melanosis may be due to freckles, xeroderma pigmentosa, pityriasis versicolor, follienlar lichen planers, generalized verruca plana etc. Leucomelanosis may be from genetic, xeroderma pigmentosa, pityriasis versicolor, PKADL etc. Spotted keratosis may be due to genetic syringoma, trichoepithelioma, pityriasis rubra pilaris, tuberenlosis verrucose cutis, verruca vulgaris, adenoma sebeceum, Darier's disease and many others. Diffuse keratosis may be from genetic, psoriasis, ichthyosis, scleroderma, mechanical (bare footed sole) and many others. Arsenical skin lesions are non itchy but itchy skin diseases like scabies, seborrheic dermatitis, contact dermatitis, eczema, ring worm, lichen simplex, lichen planus may be associated with Arsenicosis. Hence we should be open-minded and differentiate Arsesnicosis from other skin disorders and determine whether they are associated with Arsenicosis.

Retired Professor of Dermatology, The Calcutta School of Tropical Medicine, Calcutta

SAHA'S CLASSIFICATION OF STAGES & GRADES OF ARSENICOSIS

Saha Kshitish Chandra

ARSENICOSIS in West Bengal, India and Bangladesh was first detected by the author in 1982 and 1984 respectively. Periodical field survey since 1983 showed increasing incidence of varying severity. Confirmation of the disease of ARSENICOSIS was done by finding high arsenic values in consumed water, urine, nails, hair and skin scales by estimating samples by Flow Injection Hydride Generation Atomic Absorption Spectrometry method at School of Environmental Studies, Jadavpur University, Calcutta, India.

ARSENICOSIS has been classified by the author into 4 stages, 7 grades and 20 subgrades. The 4 stages are 1) Pre- clinical 2) Clinical 3) Complication and 4) Malignancy. Pre- clinical (stage I) is grade O with 2 sub grades. "Oa" (labile or blood-1) Melanosis 2) spotted keratosis in palms/soles, 3) diffuse keratosis in palms/soles and 4) Dorsal keratosis each having 3 sub grades (1abc, 2abc, 3abc, 4abc). Complications (stage III) is grade 5 having 3 sub grades (5abc). Malignancy (stages IV) is grade 6, also having 3 sub grades (6abc).

The features of different subgrades are "1a"- Diffuse Melanosis in palms, "1b"- Spotted Melanosis in trunk, "1c"- Generalized Melanosis, "2a"- Nodules-6, "2b"- Nodules>6, "2c"- Large nodules,"3a"- Diffuse keratosis in soles or palms, "3b"- same in both soles and palms, "3c"- complete in whole palms and Soles, "4a"- Dorsal keratosis, "5a"- Palpable liver, "5b"- Jaundice and "5c"- Ascitis, "6a"- Malignancy- single lesion, "6b"- same 2 lesions and "6c"> 2 lesions.

Staging and grading of ARSENICOSIS are helpful to detect asymptotic cases in preclinical/ sub-clinical phase and to find the severity to the disease of prevent its progress to complication and malignancy stages.

Retired Professor of Dermatology, The Calcutta School of Tropical medicine,
EC-21, Sector-1,Salt-lake city , Calcutta - 700064, West Bengal, India.
Ph-91-0330337-5090&91-033-241-3023, E mail: kcsaha2001@yahoo.co.in

ARE ERRORS IN THE DIAGNOSIS OF ARSENIC-CAUSED SKIN LESIONS IMPORTANT?

Allan H. Smith

Advanced cases of arsenic-caused skin lesions with obvious pigmentation patterns in the skin, and keratoses on the palms and soles are easy to diagnose. However, examination of mild cases without knowledge of exposure can reveal major problems in diagnosis with marked inter-observer differences, and intra-observer changes in opinions on further examination of patients. Diagnostic decisions can be assessed in terms of sensitivity, and the proportion of false positive. From a public health standpoint, skin lesions in themselves do not have a serious prognosis, nor can be effectively treated, so errors in their diagnosis are not important provided they do not affect the provisions of arsenic-free water. In fact, if over-diagnosis results in increased testing of water, and more rapid interventions, then it is better to err on the side of over-diagnosis. In short, rigorous case definition is not a useful public health goal. But in assessing susceptibility and dose-response relationships in epidemiological studies, rigorous case definition is vital since otherwise some false positive cases may be found with low exposures when none exist, and may falsely suggest marked variation in individual susceptibility. From the standpoint of the individual patient, as with the public health goals, the key issue is whether or not the person continues to be exposed to arsenic in water. Provided exposure is prevented, perhaps under-diagnosis is better than over-diagnosis. Thus, the answer to the title of the paper is that it depends on who is asking the question, the public health professional, the scientist, or the patient.

Professor of Epidemiology, School of Public Health, University of California, Berkeley CA 94720

EPIDEMIOLOGY AND MITIGATION OF ARSENIASIS IN TAIWAN: A REVIEW

Chien-Jen Chen,

There are two arseniasis-endemic areas in Taiwan, one in the southwest and another in the northeast. Residents in the endemic area along southwestern coast started to share artesian wells in some villages in 1910s. Prevalence of dermatological lesions including hyperpigmentation, hyperkeratosis and various cancers has been found to increase with the arsenic level in drinking water showing a dose-response relationship. Increased risk of arsenic-induced skin cancer has been observed for those who had a poor nutritional status, a low serum level of beta-carotene, or an increased percentage of monomethyl arsonic acid in total urinary metabolites of inorganic arsenic. Genetic polymorphisms of glutathione S-transferases and DNA repair enzymes have been found to be associated with the risk of arsenic-induced skin cancer. A significant biological gradient has been observed between arsenic in drinking water and prevalence of blackfoot disease, a unique peripheral vascular disease ends with dry gangrene and spontaneous amputation of affected extremities. Undernourishment has been documented as an important risk factor for blackfoot diseases. Patients affected with the disease have been found to have an increased risk of cancers of the skin and various internal organs as well as ischemic heart disease. A significant dose-response relationship has been found between arsenic in drinking water and prevalence of hypertension, diabetes mellitus, ischemic heart disease, carotid atherosclerosis and cataract. Cancers of the lung, urinary bladder, kidney, liver, nasal cavity and prostate have been found to increase with ingested inorganic arsenic in a dose-response relationship. It has been documented recently that the maximum contamination level of 50 µ/L is not protective of public health. A tap water supply system using surface water from a long-distance reservoir was implemented in the early 1960s, but its coverage remained low until the early 1970s. There has been a declining trend in the incidence of blackfoot disease and skin cancers in southwestern endemic area after the implementation of tap water supply system.

Residents in the endemic area of northeastern Lanyang Basin have been using water from shallow wells in their own households since late 1940s. A dose-response relationship has been observed between arsenic in drinking water and risk of cerebrovascular disease, particularly cerebral infarction, in a recent study. The risk of urinary cancer, especially transitional cell carcinoma, has been observed to increase with arsenic in drinking water. A tap water supply system has been implementing in the northeastern endemic area since 1997, and its coverage is as high as 90% in 2000. However, the risk of arsenic-induced cancers and cardiovascular diseases remains high by now.

College of Public Health, National Taiwan University, Taipei, Taiwan

ARSENIC KINETICS IN HUMANS: EPIDEMIOLOGIC STUDY DESIGN CONSIDERATIONS

*David C. Christiani[1], Quazi Quamruzzaman[2], Mahmuder Rahman[2], G. Mahiuddin[2], Shibtosh Roy[2]

Arsenic is a known human carcinogen. However, dose-response relationships for arsenic and various health outcomes, both cancer and non-cancer remain elusive, especially at lower levels of exposure. Additionally, surprisingly little is known about arsenic kinetics in humans. Controversy remains regarding methylated arsenic compounds as markers of disease risk. Little is known about the roles of age, gender, diet, and genetics in arsenic metabolism and toxicity. We describe a new type of epidemiologic study: a molecular epidemiologic approach using repeated measures in which all factors affecting dose (ingestion, absorption, metabolism), and formulation of dose-response relationships with outcomes such as skin lesions, are assessed. Moreover, the contribution of effect-modifiers such as heritable variation in metabolism, and the phenotypic characteristics noted above, may be assessed in such a study. We are examining the following parameters in 50 families, (25 from historically known or suspected highly exposed wells, and 25 from known or suspected low or minimally exposed wells): drinking water arsenic, toe-nail arsenic; urine analysis for arsenic species (DMA, MMA, AsIII, AsV); DNA for polymorphisms in *GSTT1*, *GSTM1* and a detailed skin examination.

All parameters are measured each day for three days, four times over a year. Preliminary results reveal a median urinary arsenic exposure for the whole population to be over three-fold the current levels we find in Southwestern Taiwan. Analyses for the other biomarkers, as well as dose-response and toxicokinetic models are underway. Study strengths and limitations of this and other study designs for arsenic studies will be discussed.

*Presenter: David C. Christiani, Occupational Health Program, Department of Environmental Health, Harvard School of Public Health, 665 Huntington Avenue, Boston, MA 02115, USA. Telephone: (617)432-3323.Fax: (617) 432-3441. E-mail: dchris@hohp.harvard.edu
[1]Occupational Health Program, Department of Environmental Health, Harvard School of Public Health, Boston, MA, USA
[2]Dhaka Community Hospital, Baro Moghbazar Dhaka 1217, Bangladesh

SPECIATION OF ARSENIC METABOLIC INTERMEDIATES IN HUMAN URINE BY CHROMATOGRAPHY AND FLOW INJECTION HYDRIDE GENERATION ATOMIC ABSORPTION SPECTROMETRY

M. Alauddin[1]; D. Chowdhury[2], M. Bhattacharya[2], H. Bibi[2], S. Begum[2], M. S. Islam[2], G. Rabbani[3]

Biomethylation is the principal metabolic and detoxification pathway for inorganic arsenic in human. The end products of methylation are less toxic and more readily excreted through urine. The speciation of metabolites in urine is essential to a better understanding of arsenic metabolism, health effects and detoxification capacity of individuals exposed to arsenic through drinking water, food and environmental materials.

Speciation of inorganic and methylated arsenic in urine is an analytical challenge. We have developed a technique for separating and analysis of various arsenic species, such as, arsenite, arsenate, monomethylarsonic acid (MMA) and dimethylarsinic acid (DMA) in urine. The technique is based on chromatographic separation followed by flow injection hydride generation atomic absorption spectrometry (FI-HG-AAS). Arsenite (As^{III}) is found to be the major component in urine. The detection limit varies from 1.0 – 2.0 µg/l for various species. The technique has been successfully applied to speciation of arsenic metabolite intermediates in urine samples collected from patients in Hajiganj and Munshiganj in Bangladesh. The developmental work and the routine speciation has been carried out at the Intronics Technology Center, Dhaka. To the best of our knowledge, this is the first such study by a local research organization in Bangladesh.

Preliminary results from our findings from an arsenic affected area will be discussed. The technique will permit us to carry out routine arsenic speciation in biological tissues, essential for toxicological and epidemiological studies.

[1]Wagner College, New York USA
[2]Intronics Technology Center, Dhaka, Bangladesh
[3]International Center for Diarrhea and Disease Research, Bangladesh

CHRONIC ARSENIC TOXICITY: CLINICAL FEATURES, EPIDEMIOLOGY AND TREATMENT: EXPERIENCE IN WEST BENGAL

DN Guha Mazumder

Chronic arsenic toxicity due to drinking arsenic-contaminated water has been one of the worst environmental health hazards affecting eight districts of West Bengal since the early eighties. Detailed clinical examination and investigation of 248 such patients revealed protean clinical manifestations of such toxicity. Over and above hyperpigmentation and keratosis, weakness, anaemia, burning sensation of eyes, solid swelling of legs, liver fibrosis, chronic lung disease, gangrene of toes, neuropathy, and skin cancer are some of the other manifestations.

A cross-sectional survey involving 7683 participants of different ages was conducted in an arsenic-affected region between April 1995 and March 1996. Out of a population of 7683 surveyed, 3467 and 4216 people consumed water containing arsenic below and above 0.05 mg/l respectively. Except pain abdomen the prevalence of all other clinical manifestations tested (e.g. pigmentation, keratosis, hepatomegaly, weakness, nausea, lung disease and neuropathy) were found to be significantly higher in arsenic exposed people (water arsenic > 0.05 mg/l) compared to control population (water arsenic level < 0.05 mg/l). Incidence of pigmentation, keratosis and hepatomegaly corresponding to various arsenic dose exposure was found to have a linear relationship proportionate to increasing exposure of arsenic in drinking water in both the sexes ($P < 0.001$). The significantly high incidence of hepatomegaly observed in the Arsenic exposed group compared to control population could not be incriminated to any of the common etiological factors associated with hepatomegaly in the tropics.

The prevalence of cough, shortness of breath, and chest sounds (crepitations and/or rhonchi) in the lungs rose with increasing arsenic concentrations in drinking water. These respiratory effects were most pronounced in individuals with high arsenic water concentrations who also had skin lesion. Prevalence odds ratio (POR) estimates were markedly increased for participants with arsenic induced skin lesions who also had high levels of arsenic in their current drinking water source (≥ 500 µg/l) compared with individuals who had normal skin and were exposed to low levels of arsenic (< 50 µg/L).

Therapy with chelating agent DMSA was not found to be superior to placebo effect. However, therapy with DMPS caused significant improvement of clinical condition of chronic arsenicosis patients as evidenced by significant reduction of total clinical scores from 8.90 ± 2.84 to 3.27 ± 1.73; $p < 0.0001$. Most significant improvement was noted in regard to the clinical scores of weakness, pigmentation and lung disease. No DMPS related adverse effect was noted in any of the DMPS treated cases. Total urinary excretion of DMPS treated cases was found to increase significantly following drug therapy, while no such increase was noticed in placebo treated cases.

Efficacy of specific chelation therapy for patients suffering from chronic arsenic toxicity has further need to be fully substantiated. However, supportive treatment could help in reducing many symptoms of the patients. Treatment in hospital with good nutritious diet has been found to reduce symptom score in a subset of placebo treated patients in West Bengal during the course of DMSA trial. High protein containing diet possibly helps in clearance of inorganic arsenic (more toxic) by increased methylation. Thus people should be urged to take food containing proteins in good quantity either from animal source or if unable, from vegetable sources like pulses, soybeans, wheat etc. People should be advised to stop drinking arsenic contaminated water or exposure to arsenic from any other source.

The various clinical manifestations should be treated symptomatically.

Professor of Medicine and Gastroenterology (Rtd), Investigator, Arsenic Research, Institute of Post Graduate Medical Education & Research, Kolkata – 700 020 India

NEUROPATHY IN CHRONIC ARSENIC TOXICITY DUE TO GROUNDWATER ARSENIC CONTAMINATION IN WEST BENGAL, INDIA

Subhash Chandra Mukhopadhyay[1], Mohammad Mahmudur Rahman[2], Kunal Paul[2], Uttam Kumar Chowdhury[2], Dilip Lodh[2], Chitta Ranjan Chanda[2], Dipankar Chakraborti[2]

Varied neurological involvement due to arsenic exposure can damage both the peripheral (PNS) and the central (CNS) nervous system components. But CNS effect is less frequently observed. Arsenic neuropathy is the commonest type of peripheral neuropathy due to metal or metalloid far exceeding neuropathies caused by lead, mercury or other metals.

In our prospective field studies in villages and districts of West Bengal, India, we have examined a sizeable number of patients of chronic arsenic toxicity due to consumption of arsenic contaminated tube-well drinking water for evidence of peripheral neuropathy along with other clinical manifestations. We are presenting here two study groups:

Group A: 413 patients from villages of Murshidabad and Nadia districts of West Bengal, India.

Group B: 38 patients from a village of Burdwan district of West Bengal, India.

Clinically, arsenic neuropathy was diagnosed in the patients with arsenicosis only after exclusion of all other possible causes and alternative explanations. All patients had arsenical skin lesions.

In Group A, clinical neuropathies were identified in 154 (37.3%) of which 124 (30%) had sensory neuropathy and 30 (7.3%) had sensorimotor neuropathy. Based on rigorous criteria of neuropathy, moderate neuropathy was evident in 33 (8%) and mild (predominantly sensory) in 121 (29.3%). Other associated relevant features included tremor (9 cases), proximal limb wasting (2), diminished hearing (5), diminished vision (7), sweating disturbances (16), decreased libido (5), skin peeling (3), postural dizziness (6).

In Group B, 33 of 38 cases i.e. 86.8% had features of neuropathy. Of these, 29 (76.3%) had sensory and 4 (10.5%) sensorimotor type. Most of them (23 cases, 60.5%) were of mild degree of affection and rest (10 cases, 26.3%) was moderately affected. Associated features included tremor (1), postural dizziness (3), skin peeling (2), sweating disturbances (4).

On stopping arsenic contaminated water intake, the recovery was variable being slow and subtotal in most cases. Reexamination of sub population of neuropathic patients after one year of arsenic free water intake, definite improvement was evident in 30% and deterioration in 10%. CNS involvement such as mood changes with depression, easy irritability, anxiety disorder, lack of concentration, sleep disturbances and headache were also common findings which affected occupational and family activities of the patients of chronic arsenicosis.

Electro-physiological studies were performed in our patients to look for peripheral nerve as well as central pathway functioning. Nerve conduction and electromyographic (NCV-EMG) studies in 20 cases of moderate degree sensorimotor neuropathy revealed sensory nerve dysfunction in 9 (45%) and motor nerve dysfunction in 4 (25%). 48 cases of mild neuropathy revealed abnormal sensory nerve function in 13 (27%), abnormal motor nerve function in 8 (16.7%), delayed F latency in 3 (6.3%) and EMG changes in 2 (4.2%). The type of involvement was more axonopathic than myelinopathic. Evoked potential studies performed in 20 cases were largely normal except in few. In 2 cases visual evoked potential amplitudes were reduced. In another 2 cases abnormal inter-peak latencies was observed that in brainstem auditory evoked potential study.

[1]Department of Neurology, Medical College, Kolkata, India
[2]School of Environmental Studies, Jadavpur University, Kolkata, India

ARSENIC EXPOSURE AND RESPIRATORY EFFECTS

Abul Hasnat Milton[1], Ziaul Hasan[1], Atiqur Rahman[2], Mahfuzar Rahman

A large proportion of the population in Bangladesh has been exposed to naturally occurring inorganic arsenic through their drinking water. A prevalence comparison study of respiratory disorders among subjects with and without arsenic exposure through drinking water was conducted in Bangladesh. Characteristic skin lesions, keratoses and pigmentation alteration, and water arsenic level confirmed the arsenic exposure. Three villages were selected from health awareness campaign programs. Participants of these courtyard meetings who had suspected skin lesions. i.e., keratosis, hyperpigmentation and hypopigmentation, were examined by a well-trained medical officer to confirm the diagnosis. Unexposed subjects were randomly selected from another village, where tube-wells were not contaminated with arsenic. We interviewed and examined 218 individuals irrespective of age and sex from these villages. The arsenic level in their drinking water was measured and the mean arsenic level was 614µg/L (ranged from 136 µg/L to 1000 µg/L). The information regarding respiratory system sign and symptoms were also collected. There were few smokers, and analyses were therefore confined to nonsmokers. The overall crude prevalence (or risk) among the exposed subjects for chronic cough, and chronic bronchitis, was three-fold. Age exerted as slightly negative confounding. The crude prevalence ratios were markedly increased for female participants compared to male participants. The crude prevalence ratio for chronic bronchitis and chronic cough amounted to 2.1 (95% CI 0.7-6.1). The prevalence ratios for chronic bronchitis increased by increasing exposure, i.e., 1.0, 1.6, 2.7 and 2.6 using unexposed as the reference. The prevalence ratios for chronic cough were 1.0, 1.6, 2.7 and 2.6 for the exposure categories, using the same unexposed as the reference. The dose-response trend was same (P<0.1) for both the conditions. These results add to evidence that long-term ingestion of arsenic exposure can cause respiratory effects.

[1]Chief, Arsenic Cell, NGO Forum for Drinking Water Supply & Sanitation, Dhaka, Bangladesh
[2]Bangobandhu Sheikh Mujib Medical University, Dhaka, Bangladesh

SPECIATION OF ARSENIC COMPOUNDS [AS(III),AS(V),MMA,DMA] IN HUMAN URINE FROM AN ARSENIC EXPOSED AREA IN BANGLADESH

Uttam Kumar Chowdhury[1], Dipankar Chakraborti[1], Mohammad Mahmudur Rahman[1], Kunal Paul[1], Dilip Lodh[1], Chitta Ranjan Chanda[1], Shibtosh Roy[2], Quazi Quamruzzaman[2], N. Chandra Skaran[3], Tarit Roychowdhury[3], Tadashi Uchino[3], Hiroshi Tokunaga[3], Masanori Ando[3]

Urinary arsenic is generally considered as the most reliable indicator of recent exposure to inorganic arsenic and is used as the main biomarker of exposure. However, due to the different toxicity of arsenic compounds, speciation of arsenic in urine is generally considered to be more convenient for health risk assessment than measuring total arsenic concentration. Additionally, it can give valuable information about the metabolism of arsenic species within the body. In our study, for exposed group - 42 urine samples were collected from Datterhat (South) village of Madaripur district, Bangladesh and an average arsenic concentration in their drinking water was 376 μg/l (range 118 to 620 μg/l). For control group 27 urine samples were collected from a non-affected district, Badhadamil village of Medinipur district, west Bengal, India, where arsenic concentration in their drinking water is below 3 μg/l. The arsenic species in the urine were separated and quantified by using HPLC-ICP-MS.

Finding shows that the average concentration of urinary arsenic metabolites of adults and children were about 23 & 25 times higher than the corresponding control group. Results also indicate that average total urinary arsenic metabolites in children's urine is higher than adults and total arsenic excretion per kg body weight is also higher for children than adults. For arsenic species between adults and children, it has been observed that inorganic arsenic (In-As) in average is 2.57% and MMA is 6.56% lower for children than adults while DMA is 9.14% (average) higher in children than adults.

The efficiency of the methylation process is also assessed by the ratio between urinary concentration of putative product and putative substrate of the arsenic metabolism pathway. Higher values mean higher methylation capacity. Results show the values of the MMA/In-As ratio for adults and children is 0.92 vs. 0.73 respectively. These results indicate that first reaction of the metabolism pathway is more active in adults than children but a significant increase in the values of the DMA/MMA ratio in children than adults of exposed group (8.15 vs. 4.11 respectively). It is also shown that the distribution of the values of DMA/MMA ratio with different age of exposed human group decreasing with increasing age, i.e., methylation process (2^{nd} methylation process) decreases with increasing age. Thus from these results we may conclude that children retain less arsenic in their body than adults do.

This may also explain why children do not show skin lesions compared to adults when both are drinking same contaminated water. We normally find arsenical skin lesions in children when arsenic concentration is very high (above 1000 μg/l) or medium arsenic around 500 μg/l with poor nutritional status.

[1]School of Environmental Studies, Jadavpur University, Kolkata – 700 032, India
[2]Dhaka Community Hospital, Baro Moghbazar Dhaka 1217 Bangladesh
[3]National Institute of Health Sciences, Tokyo, Japan

ANALYSIS OF THE CLINICAL MANIFESTATION AND MANAGEMENT OF CHRONIC ARSENICOSIS PATIENTS

Khandaker A Asad, Mahmudur Rahman, Ainul Islam, Quazi Quamruzzaman, Nasirullah, Ranak C.M.

Dhaka Community Hospital in cooperation with the School of Environmental Studies, Jadavpur University, India, has carried out a countrywide campaign for tube-well testing and patient identification. So far, 14000 patients have been recorded.

In the past three years 400 chronic arsenicosis patients attended the outpatients department of DCH. From these, 100 patients were selected to take part in the study. Criteria for selection were those who had a fully detailed case history, who could continue to attend outpatients to be followed up and who had an estimated timeframe for drinking arsenic contaminated water. The patients came from 17 of the 64 districts of Bangladesh. Of the 100, 13 were below 15 years, 65 between 15-40 years and 22 above the age of 40. There were 60 males and 40 females. Sixty-five were admitted as inpatients because of the severity of their symptoms, 26 of these showed signs directly related to chronic arsenicosis. Nail and urine samples were collected from the patients for analysis to confirm the diagnosis of chronic arsenicosis. Routine blood samples were conducted for all patients. Biopsy from ulcerated lesions, arsenical keratosis nodules and some special investigations for symptomatic patients were done. All 100 patients presented with melanosis (spotted pigmentation and depigmentation) and 40 with melanosis and keratosis. The most common findings were melanosis with hyperpigmentation, which affects mostly the trunk, limbs palms, soles and tongue. Nausea and abdominal pain were the predominant gastrointestinal symptoms. Respiratory symptoms of cough with breathing difficulties were recorded in 25 patients and burning sensation of body and numbness of lower limbs were reported by 30 patients. Of the 65 inpatients, 12 had developed carcinoma of the skin (squamous cell carcinoma) 7 suffered from vascular complication, edema with ischaemic change of limbs (fingers and toes) and 7 patients suffered from chronic bronchitis. These complications are known to be directly related to chronic arsenicosis. The remaining 39 patients suffered from other diseases along with skin manifestations of chronic arsenicosis. While ischaemic heart disease, hypothyroidism and hypertension are definitely associated diseases, the findings of bronchectasis, urinary tract infections, filariasis and malabsorption syndrome are yet to be demonstrated to correlate with chronic arsenic poisoning and may possibly be unrelated. Although three patients were diagnosed with high blood pressure and this is reported as a definite correlate with chronic arsenicosis. No patients in the sample suffered from other known related diseases such as diabetes mellitus nor was any patient suffering from urinary bladder carcinoma or carcinoma of the lungs, known long term outcomes of arsenic poisoning.

Primarily all patients received advice to drink only arsenic free water. They were also given good nutrition, nutritional advice and antioxidants, vitamins A, C and E. Patients reported feeling better with reduced symptoms of bodily burning sensation under this regime. However it is important to note that the roles of nutrition and antioxidants in treating chronic arsenicosis are still unclear. The majority of these patients had poor nutritional status and an overall improvement in nutritional status helps combat ill health. Patients with squamous cell carcinoma, basal cell carcinoma and ischaemic vascular complications were treated with conventional treatment protocols. Cancer patients were treated with chemotherapy and radiotherapy. Out of 7 vascular complications, 6 patients needed amputation of limbs at various levels. Out of 12 cases treated for cancer, 2 died.

In conclusion, research is needed to understand the epidemiology of chronic arsenic poisoning. Advanced scientific research in the field of nutrition and the effect of antioxidants will provide useful information for patient management. An understanding of the genetic and molecular biological impact of chronic arsenicosis is also necessary to determine the long-term effects of this disorder. This is particularly important in the field of cancer and reproductive health. Research in these fields is vital to help millions of people who are exposed to this poison that affects many countries.

Dhaka Community Hospital, Baro Moghbazar, Dhaka 1217, Bangladesh, Email: dch@bangla.net

AMPUTATION ARSENICOSIS PATIENT REHABILITATIVE BY PHYSIOTHERAPY

Abdus Salam

The paper describes the arsenicosis patients' rehabilitation of amputation at DCH following physiotherapy. Aim and objects of physiotherapy are to rehabilitate, restore privileges and reputation, ie. to bring the patient to the point where s/he can again take his/her place as an independent member of the society. The amputee needs time and help to overcome both the physical and psychological aspect of losing a limb. The support and encouragement from all the multidisciplinary team, family and friends are essential parts of the rehabilitation process.

Physical Assessment:

(1). Muscle strength and joint mobility
(2) Balance ability or posture sitting, standing and transferring
(3) Functional ability: dressing and personal independence and ability to walk
(4) Circulatory Status – color of skin, sensation of hand to feet, skin breakdown or abrasions
(5) Previous medical problems.

Social assessment is based on the patients' social information: occupation, marital status, housing and general lifestyle etc.

Postoperative Program:

1. To prevent joint contractors
2. To strengthen and mobilize the unaffected leg
3. To strengthen and co-ordinate the muscles controlling the stump.
4. To strengthen and mobilize the trunk and retrain balance.
5. To teach the patient to regain independence in functional activities
6. To teach crutch walking without prosthesis
7. To control edema of the stump and commence early ambulating.
8. Re-education of sensation in the healed stump
9. Successful discharge into the community.
10. Chest Physiotherapy.
11. To train activity of daily living

Result and Functional Activities: The expected outcome for each of the patients is identified. The patient should achieve complete independence in all activities of daily living. Avoiding any of these activities could lead to loosening of the prosthesis from problems that arise in the stump. The need for these limitations must be clearly understood by the patient.

Conclusion: The individual with lower or upper extremity amputations can be helped to return to a full and useful life following the loss of the limb. A program of postoperative care that includes consideration of physical and emotional needs will enable most patients to become functional prosthetic users.

Department of Physiotherapy, Dhaka Community Hospital, Baro Moghbazar, Dhaka-1217, Bangladesh

ARSENIC: AN ONCOLOGIST'S POINT OF VIEW

Sthabir Dasgupta

The Situation

Strong evidences have been provided to indicate that arsenic in drinking water is causing human lung and bladder cancers.(1) These organs seem to be especially sensitive to arsenic-linked carcinogenesis. Arsenic is also a known carcinogen specifically linked to skin cancer.(2) Its long term exposure may also cause melanosis and hyperkeratosis, conjunctivitis, hyperpigmentation and even gangrene in limbs.

The Cause

The underground aquifers are essentially anaerobic environment. This environment is transformed to aerobic one, due to heavy withdrawal of ground water in conjunction with fluctuation of water table and thousands of boreholes. The newly introduced oxygen oxidizes the arsenopyrites and releases arsenic to water. This is the main cause of arsenic pollution in ground water. It is unknown so far the dose-related effects of this pollution on the environment as a whole(3); but a significant dose-response relation between risk of cancers of the urinary organs and arsenic exposure was observed in other studies.(4) Over and above this truly scientific cause of arsenic poisoning, there is a social cause also. If there is naturally occurring nitrogen-fixing crops in the field, one need not apply nitrogen fertilizer that contaminates the ground water and forces one to pump deeper and deeper causing arsenic poisoning, as in the case of Bengal. The people of Bengal had to drill deeper wells in order to water the new ''advanced' crops, which need five times more water. As one goes deeper into the ground to obtain water, one comes into contact with arsenic residues, resulting in contaminated water. Because of well drilling since the sixties in the Ganges delta numerous millions of people have been exposed to toxic amounts, and hundreds of thousands demonstrate signs of chronic poisoning.(5) Some other places also experience fluoride or selenium poisoning. Environmental sustainability requires diversity. All that rich diversity, which naturally fixes nitrogen and provides diverse nutrients, is wiped out by the Green Revolution. The Green Revolution required 'new' technologies. However, this group of technologies has such dire consequence on the environment and people's health.

The Mechanism

The carcinogenic mechanism of arsenic is not well understood, but it is believed that it is bioactivated mainly in the liver, producing carcinogenic methylated metabolites that act in the bladder and lungs. It is also assumed that other toxic agents could also participate in co-carcinogenic activity. A possible genetic predisposition has also been contemplated.

The Prevention and Treatment

A changed water technology and chemical precipitation of arsenic in the drinking water can reduce the size of the problem, although the late sequelae, such as the malignant diseases are possibly uncontrollable. And neither any antidotal treatment of exposed individuals has yet been outlined,(6) except for skin lesions. In these lesions as also in the lesions in the central nervous system, a specific antidote against arsenic poisoning discovered during the Second World War [R A Peter and his associates], popularly known as BAL may be used in solution or as an ointment. Its technical name is 2, 3 dimercapto-propanol which was originally devised as a remedy for injuries caused by arsenic containing war gas called leunsite.

Most recently however, the scientists of the School of Environmental Studies and the Council of Scientific and Industrial Research (CSIR) in India have jointly devised a way to remove arsenic from water. They have prepared filters using fly ash. It has also been shown by some researchers that water treatment that works by coagulation with ferric salts can reduce the concentration of arsenic in drinking water enormously. This kind of water treatment has started working in some parts of the world, such as Chile only recently. However, the effects of this reduction on cancer rates are not yet measurable as the latency period is between 20 and 30 years.(7)

The Paradox

Paradoxically, arsenic is now being used successfully to treat leukemia.(8) Opinion remains divided as to whether the treatment itself might be carcinogenic.

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Consultant Oncologist, 140/D Sarat Bose Road, Kolkata, India

FREE RADICALS, ARSENICOSIS AND ANTIOXIDANTS

Omar Akramur Rab

Free radicals are unstable. Free radical oxidative stress has been implicated in the pathogenesis of a variety of human diseases. Cells exposed to arsenic produced about three times as many damaging free radicals as other cells.

Inorganic arsenic increases the rate of formation of active oxygen species, including superoxide anion radicals (02), hydroxyl (OH) radical through a chain reaction. The mechanism of arsenic toxicity to individual cell type has historically centered around the inhibitory effects on cellular respiration at the level of mitochondria. Disruption of oxidative phosphorylation and concomitant decrease in the cellular levels of ATP are thought to be important central events of arsenic induced toxicity evoking increased production of hydrogen peroxide. These effects could cause formation of reactive oxygen species resulting in oxidative stress. Studies also clearly demonstrated that the generation of free radicals within minutes of arsenic exposure could lead to gene mutations and death of the cell.

This exposure to arsenic causes long term non-cancerous and cancerous health effects particularly skin cancer, bladder and lung cancer. The follow up studies showed that patients with chronic arsenicosis, once affected, may not recover on stopping of drinking arsenic contaminated water. The International Agency for Research on Cancer (IARC 1980) classified inorganic arsenic compounds as skin and lung (via inhalation) carcinogens. Arsenic’s cancer-causing properties may stem from the production of DNA-damaging particles (free radicals). Antioxidants such as beta-carotene, vitamin C and vitamin E, which mop up free radicals and may prevent arsenic toxicity specially cancer.

Antioxidant functions of Beta Carotene (Provitamin A):
A chain breaking antioxidant. It stops the chain reactions by trapping free radicals, has an anticancer property particularly skin, lung, GIT, bladder etc. The best-established chain of evidence for cancer is available for beta-carotene (J.Vit. Nutr. 1993). It is very safe. In contrast, Vitamin A is a very weak antioxidant with no anticancer activity.

Antioxidant functions of Vitamin E:
Protects critical cellular structures against damage both from free radicals and from oxidation products. Protects against cancer induction by:

a. Enhancing immune system
b. Protecting DNA from mutagens
c. Enhance immune response vitamin E in high level found safe (Ref: vitamin intake and Health: A scientific Review, 1991)

Antioxidant functions of vitamin C:
Protects DNA from free radical damage and mutagens. Reduce the toxic, mutagenic, carcinogenic effects of many environmental pollutants, heavy metals, pesticides etc. (Calabrese, 1985)

Protects cancer by:

a. Enhancing immune system
b. Blocking nitrosamine
c. Enhancing hepatic clearance of toxins (Glatthaar et al, 1986)

Has immuno-stimulatory effect through enhancement of neutrophil function (Anderson, 1981a).

The clinical symptoms of arsenic toxicity appears insidiously after 6 months to 2 years or more and indeed there is a minimum time gap of five years between first exposure to arsenic and initial cutaneous manifestations (Guha Mazumder et al, 1998). The results of several studies also demonstrate that negative skin signs are no assurance of low risk for cancer development (Tsuda et al, 1995).

Moreover, the hard fact is that the degree of human sufferings caused by arsenic is beyond comprehension in Bangladesh. Therefore, combination of antioxidants like beta-carotene, vitamin E and vitamin C would protect or cut the level of free radicals in the arsenic exposed cells and thus may protect from long term arsenic toxicity in particular skin, bladder and lung cancer.

Manager, Medical Service Department, SQUARE Pharmaceuticals Ltd. Bangladesh

COMPREHENSIVE ARSENIC MITIGATION ACTIVITIES IN 20 UPAZILAS BY UNICEF

J.W. Rosenboom, C. Davis, S. Islam, G. Rozario

Background

In July of 1999, UNICEF Bangladesh started its first arsenic mitigation project, in five upazillas. In March of 2001, 15 more upazillas were added to the project area, bringing the total to 20. A further 25 upazillas were assigned to UNICEF in late 2001, and activities there will start early in 2002.

An officially recognized communication campaign was created during the early stages of the 5 upazilla action research project, and that same program saw the development of the four-part integrated mitigation strategy which continues to be used today, consisting of: 1) blanket testing of tube-wells, 2) communication for awareness, 3) searching for and assisting arsenicosis patients, and 4) providing safe water supply options.

Status

As of December 2001 some of the accomplishments in the 20 upazillas are:

Wells tested	385,000	Household arsenic removal	13,211
Red (≥50 ppb)	67% (258,000)	Community arsenic removal	67
Green (<50 ppb)	33% (127,000)	Household alternative supply	437
Out of order	2.8% (9,151)	Community alternative supply	389
Patients identified	>2,500 (est.)		

In addition to those quantitative indicators, survey data from 11 upazillas about people's arsenic awareness and related behavior is available, which will be published in the course of 2002.

Insights

Not surprisingly given the numbers shown above, there is an enormous unmet need for safe water options. Contrary to what is often believed, safe water options *are* available, for which villagers are willing and able to pay. In all safe water options provided with UNICEF's assistance, running costs are fully covered by the users, while capital cost contributions of Tk. 2,000-240,000 (!) were made, depending on the technology used (ranging from household rain water catchment tanks to a deep well with pumped storage and distribution system). Testing can be carried out by trained village workers, but a balance needs to be struck between speed and incentive. For testing only (without patient identification) teams of two are adequate, with 2-4 teams per union.

Issues to be addressed

While there is sufficient choice of technologies to cover almost any situation or community preference, a number of issues remain to be addressed. Chief among those is to develop a strategy for rapid provision of safe drinking water in a sustainable, community-based manner. Especially making the transition from rapid arsenic screening to the much slower water supply provision is not proving to be easy, and there may be a need for interim, emergency water supply options in severely affected communities. Monitoring of arsenic removal plants will need more and more attention as their numbers grow, as will methods for the disposal or recycling of waste from those plants. In the long term, the question of re-testing of all green wells will need to be addressed as well. If all goes well, all wells in the most severely affected areas will have been tested once at the end of 2002 but this means that only about half the wells in the country will have been covered in the period since the start of mass testing in 1999. Addressing the long term demand for testing will almost certainly mean encouraging private sector involvement in providing testing services, with which some positive experience exists already.

UNICEF, GPO Box 58, Dhaka-1000, Bangladesh

ALTERNATIVE WATER RESOURCES FOR POOR VILLAGERS: EXPERIENCES FROM FIELD

Nurjahan Begum

Arsenic contamination of the groundwater of Bangladesh has become the gravest concern in the lives of millions of people of this land. Most of the districts of the country are found to have arsenic in shallow water more than the acceptable level of 50 ppb. The number of arsenic patients is increasing steadily. Poverty and inadequate level of literacy of mass people are aggravating the situation. The effect of arsenic contamination is limited not only to health hazards; social and cultural life of this country is also going to be greatly affected.

Grameen Bank's arsenic mitigation work in Kochua

Grameen Bank first started its arsenic mitigation project in 1999 in Kochua upazilla of Chandpur district in collaboration with UNICEF and DPHE. The project will end in February 2002. The objectives of the project were to test all tube-wells in Kochua, demonstrate and test various safe water options, make community people aware of arsenic and its contamination and to encourage them to drink arsenic free water, identify arsenic patients and arrange for their treatment, and involve the community in the management of alternative water resources. Kochua has 12 unions and 243 villages. We tested all of the 17787 tube-wells in Kochua and found that 17424 tube-wells (98% of the total) had arsenic more than the acceptable level (50 ppb). Only 363 tube-wells were found to have arsenic less than 50 ppb. Re-test of some 7664 tube-wells in the latter period of the project did not find any change in the situation.

Installation of safe water options

In 1999-2000 we installed and monitored various alternative water options in Kochua. These supplied community people with safe water and at the same time provided scope for testing the alternatives. Between 1999-2001 we installed and monitored 35 Pond Sand Filters (PSF), 174 Rain Water Harvesters (RWH), 30 Safi Filters, 1500 Kolshi Filters, 6 Chari Filters, 6 2-Bucket Filters, 14 Tara Pumps, 72 ALCAN Filters, 53 Shapla Filters and 51 Canada-Bangladesh Filters. These water options were provided either for demonstration or through cost sharing. Some of the options were for household use, but most of them for community level use. Some were for treating surface water (pond, river, dug-well, canal etc.); others for treating arsenic contaminated tube-well water using particular media.

Experience with arsenic removal technologies

Some of the arsenic removal options are indigenous, others imported. Most of the media used in these options are imported, as they are not produced in the country. The cost is also high and beyond the capacity of poor people. Adequate research information about the agents is also not available. The more effective a removal system, the costlier it is. Disposal of toxic sludge of the arsenic removal options is not 100% pollution free and this may become a big environmental problem in the future. How much and how effectively the technologies are removing arsenic, how safe the present sludge disposal systems are and whether they are effective in the long term – are important questions yet to be answered and unknown to those for whom all our activities are meant.

One of our experiences is that, in most cases, even after a lot of motivation work by field workers, users are not willing enough to take up the responsibility of maintaining the options and ensuring safe water by regular tests by themselves. But large options of arsenic removal are more expensive and thus demand community level management. In the case of large options of arsenic removal, the benefit may go to a few families instead of the whole community.

In the case of Pond Sand Filter, however, my personal experience is that it is more acceptable to villagers and they are interested in its maintenance. There are, of course, some problems with this option. Owners of ponds are not much interested to give up their ponds for public use at their own costs. But we have observed that continued motivation brings better responses from the pond owners. Motivating pond owners to give up their private ponds for public use (at their own cost) is a matter of time, but some mechanism (either free use or for compensation) will ultimately develop, as the arsenic problem is a permanent problem for the whole community. Filters provided for family level use are also expensive, particularly for the poor, and are not yet proved fully safe. Proper maintenance of any option by the poor will always be a problem.

Community people, particularly the poor and illiterate ones, are found to drink water from "Red" tube-wells, even after being made aware of the dangers, as arsenic poisoning does not occur instantaneously. They are also skeptical about the efficiency of the options in removing arsenic. Lack of adequate facility in the locality for treatment of arsenic patients makes them even more frustrated.

Concluding remarks

The quality of treatment of arsenic contaminated water by various options is not yet above question and technologies available for this are too expensive particularly for the poorer section of the community. Community level participation and cost sharing by community people for alternative water options are not yet strong enough for sustainable management of such options. So we are of the opinion that technologies treating surface water should be preferred, particularly where surface water is available throughout the year. These options should be small and easily manageable in the household. The feeling that we are to live with arsenic and pay for safe water is coming up, although slowly. As long as that feeling is not grown strong enough, we should prefer small and family level options that treat surface water instead of larger options that demand community level participation and management. Cheaper but more effective water options for the extreme poor should also be developed.

General Manager, Grameen Bank

A DUGWELL PROGRAM TO PROVIDE ARSENIC FREE WATER IN NORTH 24 PARGANAS, WEST BENGAL

Meera M Hira Smith

In 1982 Dr. K. C. Saha, a dermatologist of Calcutta, West Bengal, identified the first patients with skin lesions from the district of 24 Parganas which led him and others to search for a cause. The cause was soon identified as arsenic in drinking water, but even today, 20 years later, large numbers of people continue to drink arsenic contaminated water and patients are increasing in number.

The Dug Well is a program chosen to be implemented in some villages of North 24 Parganas by the adoption of villagers. It has been formulated to provide arsenic free drinking water by constructing shallow, concrete dug wells designed to tap the water of the unconfined aquifer that contains arsenic of permissible level in the target region. The conventional design is modified by use of tube well hand pumps to withdraw the water and a built-in mechanism of disinfecting the water. The project includes community involvement, training and awareness of drinking arsenic free water, and also monitoring of the dug well water for arsenic and harmful pathogens. Disinfecting of the water and regulating the water hazard diagram are also included in the training program. The plan is to make the system sustainable at the village level using indigenous labor and materials.

Project Well, Oakland, California

DUGWELL – A POTENTIAL ALTERNATIVE SAFE WATER OPTION TO COMBAT THE DEADLY MENACE OF ARSENIC POISONING IN RURAL BANGLADESH

Md. Jakariya

Bangladesh faces multi-faceted problems in relation to groundwater. At present there is a new threat - arsenic contamination in groundwater. BRAC, the largest non-governmental development organization in Bangladesh, is testing a community-based arsenic mitigation program in two *upazillas* (Administrative unit, equivalent to sub-district) of Bangladesh.

To mitigate the arsenic problem, a number of alternative safe water options are available in Bangladesh. Some of these options are based on surface water and some are based on treating the arsenic-contaminated water. None of the options tried so far under this community-based project was as easy as to get water from tube-wells. It has been observed that the percentage of acceptance of different alternative safe water options was not only unsatisfactory but also varied greatly among the communities (Chowdhury et. al. 2000).

The sustainable option should have to have community acceptability both in terms of technical and financial viability. Therefore, it is urgently important to find out a sustainable community acceptable solution of this deadly menace in order to stop further contamination. It has been observed that acceptance of dugwell in these two upazillas by communities is comparatively high and according to a latest survey all the dugwells are in use in the communities. Water quality of the dugwells was tested in laboratory on a regular basis and still none of the users complained about stomach upset due to drinking water from these dugwells.

BRAC renovated about 100 dugwells in these areas. This paper describes the potentiality of using dugwells as a source of sustainable safe drinking water for the millions of arsenic-affected people of Bangladesh.

Coordinator, Environment Group, Research and Evaluation Division, BRAC, 75 Mohakhali, Dhaka

DUG WELL – AN OPTION OF CHOICE

Ranajit Das, Jabed Yousuf Biduyat, AE Shohel, A Rahaman, TH Protik, Ariful Islam, S Islam, SM Basit, Ranak C.M.

Bangladesh is a country with one of the highest amounts of per capita sweet water reserve in the world, with more than 2000 mm. yearly rainfall. Many of the rivers originate from the Himalayas and keep the soil of Bangladesh wet throughout the year. This surface water was once the source of water for human use throughout Bangladesh. Widespread use of underground water was introduced in the sixties and seventies to protect the population from epidemics of diarrhea dseases. The technology used was so affordable and the water so acceptable that within three decades more than 95% of Bangladesh's communities use this water. It became a replicable model in many developing countries. The discovery of arsenic in this water source has turned the tube-wells that were a huge investment for a poor country into a white elephant. Alternative safe water supplies are being sought; the dug well is one such option.

The dug well is a traditional source of potable water, used for thousands of years and even after the tube-well culture, many villages still use dug well water. In Bangladesh dug wells are not of the artesian type. The wells are usually at a depth of 30 to 50 feet and the water comes from the nearby ground by filtration process. Water is available throughout the year in most of Bangladesh other than the coastal and hilly areas. So far no dug wells have shown high concentration of arsenic.

This paper describes the identification of 128 existing old dug wells, many of which were not actively in use, in 15 highly arsenic contaminated areas. Some of these wells along with a few newly constructed dug wells (ring type) were selected for a social acceptability comparison. The wells were divided into three groups. One group of wells was just renovated, protected from external contamination but kept uncovered; the second group was covered after renovation and protection; the third group had hand pumps attached to the well to keep away any external contamination after the usual renovation and protection. Water samples were regularly tested and were found to be within safe limits and no increased incidence of diarrhea diseases were reported during the study.

Dhaka Community Hospital, Baro Moghbazar, Dhaka-1217, Bangladesh

SOCIO-CULTURAL IMPACT OF ARSENICOSIS IN RURAL BANGLADESH

Mahuba Nasreen and Khondoker Mokaddem Hossain

Arsenic, a toxic element, is teaching a bitter lesson to mankind, particularly to those who have been suffering from arsenicosis. The excessive level of presence of arsenic in drinking water is redefining water from 'life saver' to a 'threat' to human survival. Because it takes 10 to 20 years, depending on the amount of arsenic accumulated in the body, to be identified as arsenic patient, people's response to the disease is not so prompt. Vast majority of the rural people is inextricably linked with the contaminated water for their daily survival. It is reported that most of these people neither had the idea of arsenic contamination, nor the future impact of the catastrophe of arsenicosis. Arsenic contamination is getting enough attention, however, scientific research on arsenicosis is scanty in Bangladesh. Government and other agencies are mainly attentive to the identification, mitigation and supply of safe drinking water but little has been done to discover the pains the arsenic patients are going through. Although some organizations are identifying arsenic patients, almost nothing has been done for their rehabilitation. Because arsenicosis is related to health hazards, scientists, especially medical researchers are dominating the field. There is almost no research on the socio-cultural or economic aspects of arsenic contamination or impact of arsenicosis on society. This paper is an attempt to highlight on some of the adverse impacts of arsenicosis, with which people have to live with as victims.

Department of Sociology, Dhaka University Dhaka

ARSENIC AWARENESS AT HOUSEHOLD LEVEL

Md. Mosleh Uddin Sadeque[1], Md. Aszhar Ali

DPHE- Danida Arsenic Mitigation Pilot Project (AMPP) worked in Chaumuhani and Lakshmipur pourashavas of coastal region of Bangladesh for two years, an area of high concentration of arsenic in ground water where knowledge about arsenic was sporadic, non-existent or inaccurate. The slow pace of its effect is a cushion to people's complacency. So, effective community participation in arsenic awareness creation is a difficult task and much depends on the way members of the community are approached by the development workers.

This paper discusses the results of AMPP approaches for enduring behavioral change at individual and household level in the project areas. The arsenic awareness creation followed two popular methods of social mobilization i.e. courtyard meeting and house-to-house visit but with new synergistic approaches and five specific messages. Results show that the majority of the beneficiaries know about arsenic hazards, are motivated to drink arsenic free water and adopt project developed low cost arsenic mitigation technology. These approaches have played a pivotal role in creating an environment for appropriate behavior change, especially focusing on women who are the prime actors with respect to water management at household level. The key experiences from the piloting phase are that effective approach and specific messages can accelerate arsenic awareness creation at water users level with incredible spirit.

[1]Correspondent author: DPHE-DANIDA Arsenic Mitigation Component, R&D Field Office 1031, Guptaranga, Main Road, Maijdee Court, Noakhali, Bangladesh; Tel: 0321-61804 Fax: 88-02-9344791, E-mail: watsap@dhaka.agni.com
Department of Public Health Engineering – Danish International Development Assistance

A SUSTAINABLE COMMUNITY - BASED ORGANIZATION (CBO) AND INVOLVEMENT OF LOCAL GOVERNMENT ENTITIES (LGE)

M. Nuruzzaman,

A sustainable Community Based Organization (CBO) is an important root of development with the involvement of Local Government Entities (Union Parishad). A pilot program in six Upazilla was initiated through the Bangladesh Arsenic mitigation Water Supply Project (BAMWSP) for screening (testing of tube well and patient identification), community development and mitigation program. Targeting a specific issue (arsenic crisis in ground water contamination) an output-based five-activity package was adopted. Through a participatory approach a number of 2066 CBOs was formed according to felt need of the community with the direct involvement of local government entities. The representatives of the CBO were from the local community, members of Ward member of Union Parishad (UP), local elites, Imam, Mouluvees, and teachers. Awareness program was initiated from the beginning of screening program and continued till the end of the program. For capacity building and institutional development of UP and CBO members the local based Support Organizations (NGO) were involved. The local arsenic committee is involved to follow up the program. The CBOs are incapable of analyzing their local situation, preparing the subproject for supply of arsenic safe drinking water for the community, implementation and monitoring the subprojects.

Bangladesh Arsenic Water Supply Project (BAMWSP), House # 450, Road # 31, New DOHS. Mohakkhali, Dhaka, Bangladesh

CAPACITY BUILDING IN ARSENIC FIELD WORKER

Marzina Begum, Sabitri Ray, Altab Elahi Sohel, Ranak C.M

Different organization of Bangladesh have developed different types of training programs for dealing with the problem of groundwater contamination by arsenic in the world. In this paper the methods used by the trainers at the Dhaka Community Hospital to build up the capacity of arsenic field workers is discussed.

This training program started after detecting arsenic patients in 1996 and since then has been constantly updated as more information is gathered. Training is need-based and practical. Before training begins, the trainers visit the field to find out the needs of the community to deal with this health hazard. The trainers repeatedly visit the target work areas to update and ensure relevance in the training material. This also allows the trainers to see the problems found by the field workers and the paper briefly describes how this is reflected in the training process.

As the contamination issue is a multi-faceted problem, a clear understanding of the issues is required to address it. Community awareness may not be sufficient to understand the risk of drinking water and it may be difficult to change the attitude of the community. Any activities taken to achieve a solution need carefully planning and follow up, thus, training is on-going process.

The DCH training aims:

- To make the trainee understand the problem clearly
- To raise the need to develop awareness at the community level
- To make trainees understand how to identify vulnerable areas in the community
- To equip them with knowledge in managing arsenic patient at the community level as well as the hospital.
- To disseminate clearly the different feasible water options

To achieve these aims and build up capacity in the arsenic field workers, DCH carries out social and clinical research to enable relevant development of training materials. Training manuals and modules have been produced along with IEC material. These incorporate community recommendations through feedback mechanisms. Trainee field workers are carefully selected and the appropriate training components for their communities are used.

Training is carried out in the field and is not a one-off procedure. Updating and monitoring of work are required to ensure the success of field workers to perform their tasks.

Training Department, Dhaka Community Hospital, Baro Moghbazar, Dhaka-1217, Bangladesh

SUSTAINABILITY GUIDELINES OF ARSENIC CALAMITY OF BANGLADESH

Md. Salequzzaman

Groundwater arsenic pollution has become a serious environmental health issue of the people of Bangladesh. Till now, the issue has been taken into account as a priority agenda by the government; and many local, national and international organizations. In the true sense, 'ground water arsenic pollution' has been recognized as a famous slogan to the researchers, social workers and different academic person of the national and international community.

But very little success has been achieved for its remediation and a sustainable management program. Yet a lot of recommendations have been suggested from many national and international symposia, seminars and conferences and in national and international journals as well. The few achievements of these efforts have not been researched about the poor people who are the victims. This is mainly because of coordination among different organizations and selection of locally available, low-cost alternative solutions and treatment technologies. The paper will discuss the real barriers for the solutions of this arsenic calamity. Finally, the paper will recommend a sustainability guideline for the management of the arsenic calamity in Bangladesh.

Environmental Science Khulna University, Bangladesh and Researcher, Institute for Sustainability and Technology Policy (ISTP). Murdoch University, WA 6150, Australia, Tel. +61 893602775/9284 4222, Fax. +61 89360 6421

ARSENIC CALAMITY IN INDIA AND BANGLADESH SUB-CONTINENT – WHOM TO BLAME?

Dipankar Chakraborti

Groundwater arsenic contamination in West Bengal, India was first reported in December 1983 when 63 people from 3 villages of 2 districts were identified by health officials as suffering from arsenic toxicity. A survey report up to October, 2001 indicates that 9 out of 18 districts of West Bengal are arsenic affected and 6 million people are drinking arsenic contaminated water and around 300,000 people are suffering from arsenical skin lesions. So far during our preliminary survey 2700 villages have been identified where groundwater contains arsenic above 50 $\mu g\ l^{-1}$. In 1995 we had found three villages in 2 districts of Bangladesh where groundwater contained arsenic above 50 $\mu g\ l^{-1}$. The present situation is that in 50 out of total 64 districts of Bangladesh groundwater contains arsenic above 50 $\mu g\ l^{-1}$ and more than 25 million people are drinking arsenic contaminated water above 50 $\mu g\ l^{-1}$. So far 2000 villages have been identified where groundwater contains arsenic above 50 $\mu g\ l^{-1}$. After years of research in West Bengal and Bangladesh, additional affected villages are being identified whenever new areas in the affected districts are surveyed. We believe our present research reflects only the tip of iceberg in identifying the extent of arsenic contamination. Although the arsenic problem of West Bengal came to our knowledge almost 20 years ago, there are still no concrete plans to combat the situation. Villagers are not in any better condition than what they were in 20 years before and may even be worse. Even today many villagers are drinking arsenic contaminated water and some victims are not even aware of the cause of their sufferings.

Twenty years ago when government first came to know the problem, it took it casually and could not realize how big the problem could become in the long run. Committees were formed but they failed to suggest the solution. After 1994 no reports from arsenic committees were submitted. None of the suggestions available from the experts' reports shows us how to tackle the problem with awareness campaign, education of the villagers and people's participation. We all know groundwater is the cause of the problem and should not be extracted mercilessly and we need rules and regulations for groundwater withdrawal, but till today we have not given this its due importance. Even now we are withdrawing more groundwater than before. Researchers indicate the grimness of the future situation but it appears those who will take care of the problem do not consider it to be an issue. Even aid agencies did not consider that a toxin such as arsenic could be present in groundwater. It appears the aid agencies also neglected the whole issue. Even today we are considering water the main source of arsenic to villagers but almost no study has reported on the food chain from these affected villages, knowing fully well that tons and tons of arsenic are falling during agricultural irrigation. The mistakes that we made in the past occur even today and that is the merciless exploitation of groundwater for irrigation without even trying to adopt effective watershed management to harness our huge surface water resources and rainwater. In West Bengal and Bangladesh, we have huge surface water resources of fresh water such as rivers, wetlands, flooded river basins and ox-bow lakes. The surface water available per capita in Bangladesh is about 11,000 cubic meters. These two delta areas are known as the land of rivers and have approximately 2000-mm annual rainfall. Instead of using these resources, we are withdrawing groundwater without proper management. Proper watershed management and villager's participation is needed not only to assist the proper utilization of these huge bodies of water, but also to combat the arsenic calamity. Should we take fluoride and arsenic in groundwater as nature's preliminary warning about more dangerous toxins yet to come? Finally whom should we blame for this calamity?

School of Environmental Studies, Jadavpur University, Kolkata, India
Corresponding Author: Fax: 91 33 4735233, Email: dcsoes@vsnl.com

ARSENIC POLLUTION AND ROLE OF THE WATCH DOGS, THE JOURNALISTS

Debdut Ghoshthakur

Journalists are generally known as the watchdog of the society. They have no power to change all evils, but they can create an impression on the common mass, which may enable the Government to do the right thing. Since the mid-eighties the hidden trap of arsenic was unknown to common people. So the Government was silent. In 1983 a group of experts from School of Tropical Medicine, SSKM Hospital, All India Institute of Hygiene and Public Health reported arsenic contamination and suffering of people from a few villages of West Bengal. But the media was silent. Very brief reports were published in the dailies. Government of West Bengal was sitting over the report of experts. In 1986, surprisingly I got in touch with the arsenic patient Babulal Debnath of Binimoypara, Ashokenagar, North 24 Parganas, who had been undergoing treatment in K C Saha's laboratory. Babulal was an eye opener to us. Babulal's story created a storm. And things started to happen very quickly. Arsenic pollution in West Bengal came to limelight. This was the beginning. All the newspaper made it an issue. The Government of West Bengal was forced to constitute a task force to deal with the problem. And the ball started rolling. As a matter of fact in spite of our vigil nothing substantial has been done on arsenic issue in West Bengal from the Government side. But in one aspect we are successful. At least a good percentage of population in the nine affected districts of West Bengal now know what arsenic pollution is, what to do and why they should look for alternative source of drinking water. But still the majority does not know the severity and future danger of the problem. We have to find ways to reach them so that they and their future generations have a better living. Role of the journalists is not enough to force the Government to fight the problem with full effort. The tragedy is such that people like to read juicy stories rather than serious matter like arsenic pollution. So the media divert attention now and then to the news that the readers like the most. We need some journalist-scientist who would report the problem as well as undertaking independent research. Journalists only can make the bridge between the scientists, common man and the government. I have been following the arsenic problem of West Bengal since 1986 and have written many reports but still I feel nothing has been done. Let us hope for the best.

Chief Reporter, Anandabazar Pattrika, Kolkata, India

LET THE BAULS OF BANGLADESH SPEAK ABOUT THE ARSENIC PROGLEM

Md. Amzad Hossain

In relation to the issues of poverty and arsenic, Bangladesh has become a popular international laboratory for researchers. This paper reveals that poverty alleviation endeavors by stakeholders have so far proved to be largely futile. The mitigation of arsenic appears to follow the same trend. This paper argues that the arsenic problem in Bangladesh is mitigated by transforming the villages of the country into eco-villages in accordance with the sustainable development concept of the naturalist Baul-philosphers of Bangladesh.

The paper reveals the views of naturalist activist Harun Baul and Baul Aziz Shah Fakir of Charaikole, Kushtia on account of the arsenic problem and the possible way out that would be practical, readily implemented and sustainable. The Bauls suggest that the problem must be addressed with sustainable thinking and remedy. They assert that arsenic is a natural retaliatory phenomenon that may have been caused by the synergy of the increasing scarcity of surface water and excessive use of groundwater. The paper elucidates the Baul points of view in this regard.

The paper finally reveals the Baul solution for drinking water through the traditional production and consumption habits incorporating appropriate technology and self-reliant living. Bangladesh being a country of abounding renewables is in a position to integrate local knowledge and rural environmental infrastructure development to transform the villages of Bangladesh into eco-villages. The Bauls give the blueprint of eco-village for Bangladesh and show how arsenic in drinking water will gradually subside or lose its negative impacts on human and other species.

Action-research Scholar, Sustainable Development, Institute for Sustainability and Technology Policy (ISTP), Murdoch University, Perth, Western Australia, Australia

ROLE OF PRIVATE SECTOR IN ARSENIC MITIGATION

Quazi Quamruzzaman and Mahmuder Rahman

DCH is trying to build-up the sustainability of safe water implementation projects in Bangladesh. Unfortunately, all the expenses of these projects are met either by external funding or loans. Small local groups have little access to these financial sources.

However, the experience of Bangladesh is very interesting. Most Bangladeshi services are private, e.g. the health care system. Most of the health system is based on curative care. The primary health care is actually organized by the NGOs. About 85% of the rural people go to private practitioners, (Palli Chikishak) and in cities more than 90% of the people see doctors in the private sector. Family planning, one of the success stories of Bangladesh, was led by the NGOs but now private social marketing is foremost in selling contraceptives. The message of the benefits of oral rehydration was spread by NGOs and now the private sector has taken over production and distribution.

Drinking contaminated tube-well water is causing health, social and economic problems. The available infrastructure is in place. The Ministry of Health reaches to Union level with community clinics but public confidence is weak. Patients pay in the afternoon to see the same doctor who runs the free government clinic in the morning.

Similarly, the DPHE is mandated to provide safe tube-well water. It too reaches from central administration down to the Union level with a sub-assistant engineer posting but a survey showed that about 98% of tube-wells are privately owned. It follows that the private sector will take part in the solution to this crisis.

All over the world government action is minimized but they play a major role as regulators: they are there to see that rules are followed. If there is a rule that water sources have to be registered with the local government through the Union Chairman and tested for safety, the private sector will come forward with testing facilities that may also be monitored by legislative procedures.

Dhaka Community Hospital, Baro Moghbazar, Dhaka-1217, Bangladesh

The new US regulatory standard for arsenic and its justification

Richard Wilson

On October 31st 2001, Christine Whitman, Administrator of US EPA announced a new standard for arsenic in US drinking water of 10 ppb, to take effect in 2 years. This particularly procedure is interesting because:

(1) it is 15 years since C.J. Chen and collaborators first showed that at levels only 10 times higher than the previous standard, many cancers appeared.
(2) The risk, calculated according to previous EPA procedures, at even the new standard exceeds what EPA had previously regulated
(3) This is the first time that EPA has explicitly used cost in determining a safe level of anything.

I will show that the standard is in accordance with reasonable estimated of risk, although the detailed justification leaves a lot to be desired. An implication is that although the new standard of 10 ppb is desirable, if Bangladesh manages to meet the old standard, they will do well.