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UNU Monitor United Nations University (UNU) Monitor is a quarterly review of the UNU current research activities, publications and forthcoming projects in the area of environment and sustainable development. This issue features an article by Dr. Zafar Adeel of the environment and sustainable development programme (ESD) of the UNU. This paper presents the overview of arsenic contamination crisis in South Asia and highlights UNU's role in conducting research on issues of regional relevance. For further information, please contact Dr. Zafar Adeel, UNU-ESD programme (email: Adeel@hq.unu.edu; fax: +81-3-3406-7347) or visit the website: http://www.unu.edu/env/water/arsenic/arsenic.html.

The disaster of arsenic poisoning of groundwater in South Asia—a focus on research needs and UNU's role

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1. Overview of the arsenic crisis

The pollution of groundwater by arsenic in West Bengal (India), Nepal and Bangladesh has led to a crisis of unprecedented proportions. Some recent estimates show that more than 35 million people are potentially at risk from drinking arsenic-contaminated water (Smith et al., 2000)—this indeed brings the problem to a catastrophic scale. In comparison, the current estimate of people possibly infected by the HIV virus all over the world is around 34 million (UN AIDS, 2001). The sheer magnitude of this disaster means that we are faced with new challenges and tasks that have likely been never undertaken before.

The crisis has its roots in another worthy effort to fight water-borne diseases that had impacted this tropical region for a long time. Acute health problems, such as gastrointestinal diseases and infant mortality, were attributed to drinking microbiologically contaminated surface water. It was widely believed that using groundwater would easily circumvent the problem because groundwater at certain depths is not exposed to microbiological contamination. Presence of arsenic in groundwater was not considered a concern during the 1970s when a campaign of using groundwater as a source of drinking water was undertaken. It is now known that the alluvial aquifer that underlies the Ganges–Brahamputra river basin contains arsenic in mineral form. During the past two decades about four million wells have been installed to utilize the groundwater from shallow aquifer layers, typically <200 m deep (UNICEF, 1999). Exploitation of groundwater from these wells for drinking water and irrigation purposes has resulted in mobilizing the arsenic (Rahman et al., 2001).

Awareness about the pollution of drinking water with arsenic and the significance of the crisis has risen significantly during the 1990s. Naturally occurring and human-induced arsenic pollution in drinking water has since been discovered in many parts of the world (please see Box 1). It is now recognized that dealing with arsenic contamination in groundwater may be a problem of global dimensions.

2. The public health dimension

It is important to understand the suffering of the large population impacted by arsenic poisoning through

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Box 1
Arsenic, the silent killer

Arsenic—a metalloid element—is a natural part of the earth's crust in some parts of the world and may be found in water that has flowed through arsenic-rich rocks. Arsenic is also emitted into the atmosphere by high-temperature processes such as coal-fired power generation plants, burning vegetation and volcanic action. High concentrations of arsenic in drinking-water are found in various parts of the world including Argentina, Bangladesh, Chile, Taiwan, Hungary, India (West Bengal), Mexico, and the USA. A variety of instrumental techniques available for the determination of arsenic in water and air.

Source: WHO Environmental Health Criteria, No. 224: Arsenic (WHO, 1993).

Box 2
Health Impacts of Arsenic

Arsenic dissolved in water is acutely toxic and can lead to a number of health problems. Long-term exposure to arsenic in drinking-water causes increased risks of cancer in the skin, lungs, bladder and kidney. It also leads to other skin-related problems such hyperkeratosis and changes in pigmentation. Consumption of arsenic also leads to disturbance of the cardiovascular and nervous system functions and eventually leads to death. These health effects—sometimes collectively referred to as arsenicosis—have been demonstrated in many studies. Increased risks of lung and bladder cancer and of arsenic-associated skin lesions have been reported for consuming drinking-water with arsenic concentrations equal to or greater than 50 parts per billion (or microgram per liter).

Source: WHO Environmental Health Criteria, No. 224: Arsenic (WHO, 1993).

drinking contaminated water (please see Box 2). A large number of patients with visible or measurable health impacts are anticipated—although precise estimates for South Asia have not even been developed as yet. It is noteworthy that it takes several years of drinking arsenic-contaminated water to develop visible symptoms—although they may appear earlier in some patients. This makes estimation of the future number of arsenicosis patients quite difficult. At the moment, no reliable cure for these arsenicosis patients is available. At a minimum, ceasing the consumption of arsenic-contaminated water and improving nutritional health are shown to assist in recovering from early stages of arsenicosis. Therefore, provision of clean, safe water to all becomes an essential requirement.

3. Societal problems and lack of knowledge

Several studies on the arsenic crisis indicate a general lack of knowledge about arsenicosis, its causes and possible remedies. This is particularly true because the vast majority of the population in South Asia lives in rural areas and is not well-educated. Pre-existing notions and superstitions about the diseases triggered by arsenic exposure further worsen the situation. There is a social stigma associated with the people affected by arsenicosis, in which the disease is wrongly attributed to sins in the current or past lifetimes. This lack of awareness exists despite the concerted efforts made by many stakeholders to educate the general public and raise the level of awareness.

The arsenic crisis has also triggered a number of societal problems that were not foreseen and are still not fully recognized or understood. Recent studies confirm that worst arsenic problems are encountered by the poorest fraction of the society (WHO, 2000)—particularly those who are already undernourished. Significant gains can be made through educating the people about improving the level of nutrition in their diet and providing them support for doing so. This, obviously, has to be coupled with provision of clean and safe water.

4. Safe water options

An urgently needed measure is to provide arsenic-safe water to the people in the affected region. In the recent years, villagers have become accustomed to using groundwater from hand-operated tubewells. In view of the overwhelming dependence of the population on groundwater, point-of-use treatment of arsenic-contaminated groundwater appears to a promising option for providing safe water to the rural population. However, the broader spectrum of safe water options has to be carefully evaluated and the locally viable option(s) has to be adopted.

A number of available options can be listed here. Firstly, some deeper aquifers have been found to be arsenic-free and can be utilized for accessing to safe water. Concerns about cross-contamination of the deeper aquifers by arsenic seeping from shallow aquifers remain significantly important. Secondly, shallow hand-dug wells in some areas have also shown to be arsenic-free. These, however, are vulnerable to microbiological contamination from the surface sources. Thirdly, rainwater harvesting can also be utilized in some areas where sufficient rainfall is available throughout the year. Rainwater harvesting can potentially suffer from microbiological contamination and may require some form of treatment to ensure its safety. Fourthly, surface water may be treated at the point-of-use or at community level. Fifthly, a number of arsenic-removal

technologies can provide safe and clean water for human consumption. These can be implemented at both community and household levels; issues related to management of the arsenic-contaminated waste generated by these technologies has not been fully resolved yet. Sixthly, piped water supplies—where the source could be treated surface or ground water—are also viewed as an ideal, but expensive, long term solution.

It is important to point out that each of the safe water options has some challenges in its mass implementation in the region. The capital costs and the costs associated with effective operation and maintenance of each option has to be carefully weighed. Water supply experts at a recent meeting[1] have recommended that piped water supply should be deemed as the eventual target, but any of the other options can be utilized locally in accordance with the persisting local conditions.

5. Need for scientific research on key issues

In order to fully understand the arsenic crisis and to adequately respond to it, a number of gaps in the scientific knowledge must be filled. The research work must be undertaken with close consideration of the local conditions in the affected South Asian region. Importantly, information from scientific research should be directly fed into the development of strategies to cope with the arsenic crisis.

In a broad sense, the research areas can be grouped as follows:

- *Evaluating arsenic drinking water standard*—the current water quality standard for permissible level of arsenic in drinking water is 50 parts per billion or micrograms per liter for Bangladesh, India and Nepal. This should be carefully evaluated considering factors appropriate for the local conditions (such as average body weight, daily water consumption, etc.)
- *Finding treatments for arsenicosis*—this presents a challenge to the global medical research community to find effective treatments for arsenic poisoning related medical problems
- *Evaluating presence of other pollutants*—health impact of arsenic in the presence of other pollutants and iron must be fully studied and understood
- *Fate of arsenic in the environment*—at the moment, the fate of arsenic and its partitioning into various environmental compartments has not been fully quantified
- *Ingestion of arsenic through other routes*—once arsenic in groundwater is brought to the surface, it can enter the human body through routes other than drinking contaminated water; the significance of these other routes—such as eating contaminated foods or inhaling dust particles—should be established scientifically
- *Retention of arsenic in soils and plants*—uptake of arsenic into plants and foods from the irrigation water, its retention in soils and leaching back to shallower aquifers needs to be fully investigated

6. UNU's role in research on the arsenic crisis

The mandate of UNU envisions it to undertake policy-relevant research on issues of global concern. In the context of the arsenic crisis, UNU has undertaken research with its partners to address some of the key issues and has also been involved in formulation of policies to cope with the arsenic crisis. The focus of UNU's research has been on Bangladesh; however, the findings are applicable throughout the region and in other developing countries. In the research endeavors, UNU primarily collaborates with the Bangladesh University of Engineering and Technology (BUET). On the policy development work, UNU has partnered with a number of international and UN organizations.

As a first phase of the research work, development of economical technologies/methods for treating arsenic contamination at household level was undertaken, considering the local conditions in Bangladesh. A number of technologies were evaluated in the laboratory and at pilot scale. The research work indicated the choice of iron-based coagulation and filtration as well as iron-coated sand to be effective means of arsenic removal. Based on this work, a number of household treatment units were set up and are operating in two villages in Bangladesh. Interestingly, a number of villagers adopted the technologies at their own expense and effort, which clearly shows local acceptability of the same.

An international workshop was held in Dhaka in collaboration with BUET (BUET-UNU, 2001), entitled "Technologies For Arsenic Removal From Drinking Water." This meeting undertook the following tasks: (i) evaluated different technologies that are currently available for arsenic treatment; (ii) identified critical directions for further research on these technologies; and (iii) included some scenario development for practical application of technologies, including an economic evaluation of various alternatives. It also provided an unbiased forum for various researchers, international organizations and vendors to present their latest technological developments.

In a new joint research project with BUET, UNU is now focusing on answering some of the questions related to the fate of arsenic in the environment. The overall objectives of this research work are: (a) to

[1] International Workshop on Arsenic Mitigation in Bangladesh, 14–16 January 2002, Ministry of Local Government, Rural Development and Cooperatives, Government of Bangladesh, Dhaka, Bangladesh.

estimate overall mass of arsenic extracted with groundwater each year; (b) to estimate the quantity of arsenic deposited in agricultural soils; and (c) to estimate the arsenic concentration in soil and selected crop/vegetable, both in some arsenic-affected and unaffected areas. This research will also include an evaluation of the leaching characteristics of wastes generated from selected arsenic treatment technologies. Findings from this study will be available at the end of the year 2002.

UNU is also involved in development of strategies to cope with the arsenic crisis (Adeel, 2001). A key UNU activity was to hold a roundtable discussion "Arsenic Crisis Today—Strategies for Tomorrow" with numerous stakeholders, NGO's, UN organizations, several Ministers of State and the Speaker of the Bangladesh Assembly (3 July 2001, Dhaka, Bangladesh). This meeting provided an opportunity to discuss the emergency measures needed to overcome the arsenic crisis as well as an outlook on long-term needs. The meeting participants recommended that the local government institutions should play a pivotal role in motivating and empowering communities to make their own choices from a range of safe water options.

UNU continues to be engaged in conducting policy-relevant research and facilitating the dialogue on the mitigation of this arsenic crisis. Another key international meeting[2] is to be held in Tokyo to discuss the nexus of technological and policy issues. By working together with our partners, a significant contribution to the mitigation efforts can be made.

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[2]UNU-NIES International Workshop "Arsenic Contamination in Groundwater—Technical and Policy Dimensions." 18 February 2002, United Nations University, Tokyo, Japan.