EIA CASE STUDY: Monitoring and Pollution Mitigation – Vietnam

This case study is based on the following sources: Alaerts, Khouri, & Kabir (2001); EAWAG (2008); Jessen (2009); Luzi, Berg, Trang, Viet, & Schertenbeib (2004); Jakariya & Deeble (2008); World Bank (2004)

Project name: Monitoring and mitigation of inorganic arsenic in the Red River Delta

Date: 2002–2008
Location: Vietnam

Project Information
In the Red River Delta of Vietnam, the arsenic levels are >1000 micrograms per litre of water. The geology structure is such that the alluvial deposits in the Delta contain high levels of iron, a substance to which arsenic attaches. It is estimated that 17% of the country's population accesses their water from private tube wells. The main sources of water in rural areas of the Red River Delta include groundwater supplies such as dug wells, settling tanks, sand filters and tap water and other supplies such as surface water and rain water. From tests done, approximately 6.6 million people live within the affected zone and 1 million people are at risk for arsenic poisoning.

Arsenic is a naturally occurring substance often found in sediment in rivers, streams, lakes and aquifers. Arsenic can be released from sediments in the subsurface and enter ground water supplies when waters are stirred by large changes or shifts in the water patterns, as can occur naturally with flooding. This process is often intensified by developments such as mining operations, hydroelectric dams or even large-scale irrigated agriculture developments. Safety limits for arsenic in drinking water are typically 10 or 50 micrograms per litre. If these chemicals are released due to disturbances or changes in water levels, groundwater concentrations can reach upwards of 1000 micrograms per litre of water.

Chronic poisoning can occur if arsenic is ingested in small doses regularly over a period of 10 or more years. This buildup can eventually lead to serious health problems such as kidney lesions, high blood pressure, melanosis and neurological dysfunction as well as skin, kidney, lung and bladder cancer. Arsenic has been found in the drinking water of many countries such as Argentina, Mexico, China, New Zealand and the United States and is a severe problem in Vietnam and many parts of Southern Asia. Arsenic release into the water system is dependent on the level of dissolved oxygen in the water. The less oxygen in the water, the more easily arsenic is released. When flooding occurs, large amounts of vegetation are typically buried. As this vegetation rots, it depletes oxygen in the water, creating ideal conditions for arsenic to leech into the groundwater.

Data Collection

Testing and database development

One of the most important steps in mitigation is testing tube wells. Through this process, the extent of the problem in affected communities can be determined. Testing methods included conducting an analysis to determine the geological characteristics in the area and then taking samples of tube wells where it was probably that arsenic would be present. In total, 187,000 wells were tested across the country in 2006 and 2008. Under Vietnamese law, drinking water standards were set at 50 ppb as the maximum limit for water sources used by fewer than 500 people and a 10 ppb maximum limit for water sources used by more than 500 people.

Arsenic field testing kits were standardized (specifically for test tube wells, the most common type of well in the field). Accuracy of measurement is essential for communities to have confidence in the data. Because there are several manufacturers of arsenic testing field kits, determining which kit to use was based on previous experience. The factors considered were ease of use and accuracy of results compared to laboratory tests. In Vietnam a field test kit with a sensitivity range of 0–500 ppb was chosen. It was recommended to use only one test kit during the data collection and monitoring processes in order to maintain consistency in testing results.

The testing process involved two main phases. In the first phase 24 samples from field kits were taken from 6,900 communes, or communities distributed across the country. To verify data findings, 1,368 samples were cross-checked in a laboratory with specialized equipment. In the second phase, 150 tube wells were tested randomly in communities where at least one tested well was found to contain >50 ppb. Approximately five per cent of all phase two test samples were also tested in laboratories to check for accuracy. While there was no cross-checking mechanism to validate field testers' results from the field, supervisors helps to increase confidence in this process and reduce the number of samples that needed to be sent to the laboratory.

GIS coordinates were also collected for each well test site so that a risk map could be developed using GIS mapping software. Such a map shows the results from the water tests on a map of the region to determine where water with unacceptable arsenic levels is being consumed.

List of indicators to determine potential risk to human health from arsenic contamination in Vietnam

Indicator	Sample type	Standard	Details
Arsenic level-population >500	Groundwater	10 ppb max limit (WHO)	International standard followed for human health
Arsenic level-population <500	Groundwater	50ppb max limit (WHO)	International standard followed for human health
Total arsenic level	Sediment cores	No standard	Indicator of potential arsenic that could leech into the water system
Presence of Sulfide	Sediment cores	No standard	Some sulfide based minerals are arsenic sinks and therefore hold potential for arsenic leeching
Presence of Iron	Sediment cores	No standard	Presence of iron indicates potential for arsenic leeching into water during the iron oxidation process
Manganese level	Sediment cores	400 ppb max limit (WHO)	International standard set, mineral dangerous to child developmental growth

Because there is no cure or treatment for arsenicosis (arsenic poisoning), prevention (and water treatment) is essential. There are several key factors that need to be considered in order to mitigate the potential of the public drinking arsenic-contaminated water.

The hydrogeological factor: This refers to the natural conditions under which arsenic is leached into the water supply. It includes the variability of arsenic contamination in water within an area and the availability of alternative, clean water sources.

The water supply technology: There are two options to mitigate consumption of contaminated water; remove the arsenic from the source or provide an alternative clean source of drinking water to the public. The ability to remove arsenic from the water supply is dependent on the cost and effectiveness and availability of technology options. Likewise, the availability and feasibility of cost effectiveness affects uptake and use of alternatives by the public.

Health: Because arsenic poisoning symptoms take approximately 10 years to appear in an adult, there are many uncertainties about the long-term effects to human health. As such, there is typically less priority placed on this issue over other more immediate and apparent health crises in the public health system.

Economy and Institutions: In order to develop a strong mitigation plan, sufficient finances and institutional capacity are necessary to promote and coordinate the logistics. This type of project requires support at all levels, from setting policies and standards to operationalizing testing and education campaigns in the field.

A quality mitigation plan would include the following elements:

- Testing of water supplies to determine the extent and seriousness of the contamination.
- Public should be informed as soon as possible about the situation and potential risk to health.
- Both emergency and long-term mitigation plans should be developed.
- Reduction of arsenic levels in drinking water should be a priority.
- A diverse group of stakeholders (government, NGOs, health authorities, community members) should be involved.

In Vietnam several strategies were implemented: awareness raising, promotion of alternative safe water options and removal of arsenic from the water where possible.

Awareness Raising

In order to raise awareness about arsenic contamination on a broad scale, a communication strategy was developed. Pre-testing of the strategy in a small area was important to evaluate the effectiveness of the message, take into consideration the sociocultural context and ensure the target group was reached. In the case of Vietnam, there were two expected outcomes 1) there would be increased awareness about the consequences of arsenic contamination on health and, 2) the target population would know how to avoid contaminated water sources or how to treat water to reduce arsenic to acceptable levels. As part of the communication strategy, Provincial Centre of Preventive Medicine has become involved in areas where people are at high risk. Here the respective offices coordinate, implement and monitor Comprehensive Arsenic Mitigation Plans. The plans use media and community mobilizers to look at safe alternatives to contaminated wells. Through public consultation, pamphlets, bulletins and a DVD have been developed to promote the message.

To evaluate the communication strategy, a Knowledge, Attitude and Practice Survey (KAP) was done to review the effectiveness of messaging midway through the project. In some areas it found that negative messaging was scaring the public, so they would not drink well water even with acceptable arsenic levels (i.e., below 10 ppb). Thereafter, a more moderate campaign was adapted to compensate for this issue.

Alternative safe water options

In some Southeast Asian countries—such as Cambodia, Laos and Myanmar—alternative safe water options were provided to the public. In Vietnam, alternative safe water options were promoted, but not provided to the public. This was due in part to the amount of funding the program had. Harvesting rainwater was seen as a viable short-term solution, while household treatment through the community level was considered the better long-term option. It was important that alternatives at the household level be cost-effective and not too labour-intensive. In some areas sand filters were already being used to help remove iron from the groundwater. In these areas the filters could be modified to remove arsenic as well. A final strategy included the introduction of Water Safety Plans. In five communities with piped water supply systems, plans were developed to ensure water was free of arsenic.

Monitoring

National Database

As part of the monitoring process, a centralized database was set up to house ongoing results from data collection. Training was provided to staff on sampling procedures and surveying methods and data entry for the central database. Because the database was built based on the arsenic risk classification study and development of the arsenic risk maps, only test sample and corresponding geospatial data are currently collected. This system could be expanded to include additional information about natural disasters, well conditions and when it was drilled. Currently, the following information is collected. International standards set by the World Health Organization (WHO) were adopted by Vietnam.

List of indicators to determine potential risk to human health from arsenic contamination

Indicator	Standard
Arsenic level- population >500	10 ppb max limit (WHO)
Arsenic level- population <500	50 ppb max limit (WHO)
Manganese level	400 ppb max limit (WHO)

Ongoing monitoring

One risk of this program is that it develops a large area of impact and affects a very large population. As such, it was questionable as to whether the program would be robust enough to work as effectively in the field as in the piloted communities. Two methods to ensure the mitigation strategies are working were ongoing field testing of water after it has been treated by an alternative safe water option and administering KAP surveys to determine knowledge, attitudes and actions toward use of safe drinking water are necessary to ensure the effectiveness of the program over time. The final monitoring scheme should involve an annual health promotion campaign for families to have health checks to look for signs and symptoms of arsenic poisoning. Such ongoing data will help inform whether or not new mitigation measures need to be implemented and in which areas of the country.

References

Alaerts, G., Khouri, N., Kabir, B., & World Bank (2001). *Chapter 8: Strategies to mitigate arsenic contamination of water supply.* Retrieved from http://www.who.int/water_sanitation_health/dwq/arsenicun8.pdf

EAWAG (2008). *Predicting Groundwater Arsenic contamination in Southeast Asia from Surface Parameters*. Retrieved from http://www.eawag.ch/fileadmin/Domain1/Abteilungen/wut/projekte/predict.pdf

Jakariya, M. & Deeble, S. (2008). *Evaluation of arsenic mitigation in four countries of the Greater Mekong Region.* United Nations Children's Fund. Retrieved from http://www.unicef.org/evaldatabase/files/2008_EAPRO_Arsenic_Evaluationl.pdf

Jessen, S. (2009). *Groundwater arsenic in the Red River delta, Vietnam: Regional distribution, release, mobility and mitigation options*. Retrieved from http://orbit.dtu.dk/fedora/objects/orbit:82605/datastreams/file_5034320/content

Luzi, S., Berg, M., Trang, P., Viet. P., Schertenbeib, R. (2004). *Household sand filters for arsenic removal* (Technical report). Retrieved from http://www.arsenic.eawag.ch/pdf/luziberg04_sandfilter_e.pdf

World Bank. (2004). *Technical report: Arsenic contamination of groundwater in South and East Asian Countries.* Retrieved from http://siteresources.worldbank.org/INTSAREGTOPWATRES/Resources/ArsenicVolII_PaperII.pdf

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