Addressing Arsenic Contamination: Ensuring Safe Drinking Water and Enhancing Laboratory Testing

Metrology Asia Pacific

Author: Clarissa J. Gatchalian
Science Research Specialist, National Metrology Laboratory of the Philippines
Department of Science and Technology, Industrial Technology Development Institute
(DOST ITDI - NMLPhil)

Key messages

- Arsenic is a chemical element commonly found in nature. It can be present in various forms, including inorganic arsenic compounds which are often toxic.
- Globally, there have been documented instances of arsenic contaminating groundwater, with a significant concentration found in regions primarily located in South Asia and South America.
- Exposure to high levels of arsenic can lead to serious health issues, including skin lesions, cancer, cardiovascular disease, and neurological effects.
- Utilizing reference materials and participating in proficiency testing schemes can enhance the capabilities of water testing laboratories, leading to more reliable and traceable results and enabling timely public health risk communication.
- Policymakers should prioritize increasing the number of accredited laboratories capable of analyzing arsenic in water, especially in low-reach communities, to ensure regular monitoring.

What's the issue?

Arsenic (As) is a naturally occurring trace element in the Earth's crust. Typically found in soil and bedrock, its presence in groundwater has been identified in many regions worldwide, including in Central America, Southeast Asia, Western USA, New Zealand, and parts of Europe. [1] While some of this groundwater contamination results from volcanic activity, arsenic can also enter groundwater through human activities, such as industrial processes, mining, and agriculture. [2]

Once there, it can pose serious health risks to humans, because groundwater is widely used for drinking, food preparation and the irrigation of food crops. It has been estimated that between 94 and 220 million people are at risk of exposure to elevated arsenic concentrations in groundwater. [3]

National and international guidelines for arsenic exposure do exist; for example, the World Health Organization recommend a regulatory limit of 10 µg/L for arsenic in drinking water. However, arsenic-contaminated water shows no change in taste, odour, or appearance, which means that arsenic can go undetected if not chemically tested.

Testing laboratories therefore play a vital role in ensuring water quality meets regulatory standards, but their availability varies globally. In those regions most at risk of groundwater contamination, testing laboratories are under-funded and under-resourced, which puts communities reliant on groundwater sources at risk.

Improvement can be achieved through policies that promote the use of reference materials, and through participation in proficiency testing organized by National Metrology Institutes. These steps can enhance regional laboratory capabilities, and ensure that measurements provided by these labs are reliable and traceable to international standards.

Why is this important?

As of 2023, there were two billion people on the planet who did not have access to clean and safe drinking water. This goes against the United Nations' 2030 Sustainable Development Goals, which say that every human being has the right to access safe drinking water.

Governments in each country have a responsibility to ensure the availability and sustainable management of water and sanitation for all its people, so knowledge of water quality should be a key priority. However, according to the UN, in many parts of the world, water quality data is scarce, "due in large part to weak monitoring and reporting capacity". They write that "only 59% of the 89 countries reporting included data on groundwater." [4]

Similarly, the regulation of arsenic in water varies worldwide. It is typically managed by government agencies responsible for public health and environmental protection, such as ministries of health or environment. International organizations like the WHO also provide guidelines, contributing to a global effort to safeguard public health and ensure safe drinking water. [5]

Using reference materials and participating in proficiency testing schemes may increase the number of accredited laboratories that analyze arsenic in water, and ensure the reliability of the results obtained in the laboratory. Increasing the number of capable laboratories and ensuring the quality of test results would lead to better continuous monitoring of arsenic in water sources, timely public health risk communication, and provision of alternative water sources to communities exposed to water sources with high levels of arsenic.

Long-term exposure to arsenic-contaminated water has been linked to numerous health issues including skin lesions, cardiovascular disease, respiratory conditions, diabetes, and cancer. Addressing arsenic contamination is critical to protecting public health and mitigating the long-term consequences of exposure. [6]

The role of metrology

Metrology – the science of measurement – provides a common language for physical and chemical measurements. It plays a vital role in securing a safe, clean water supply because it forms the foundations of every reliable monitoring and testing method.

There are several ways to measure arsenic contamination in groundwater; from quick, colour-changing indicators and electrochemical tests that can be carried out in the field, to highly sensitive laboratory analysis. [7] Results obtained from these measurements are used to decide whether the water is safe for humans. Thus, ensuring a testing laboratory's reliability and international competency is essential.

All of these rely on international standards, maintained by National Metrology Institutes, but in many parts of the world, access to these measurement techniques is extremely limited. In order to fill some of the arsenic-contamination data gaps identified by the UN and others, there's a need to invest in improved laboratory facilities and capacity building amongst technicians working in impacted areas. [8] Another key link in the metrology 'chain' is proficiency testing – whereby a recognised accreditation body assesses a laboratory's performance at carrying out a specific test or measurement.

The development and provision of reference materials can improve trust in measurement equipment, as they help to ensure that any tests of water quality are reliable and traceable to international standards.

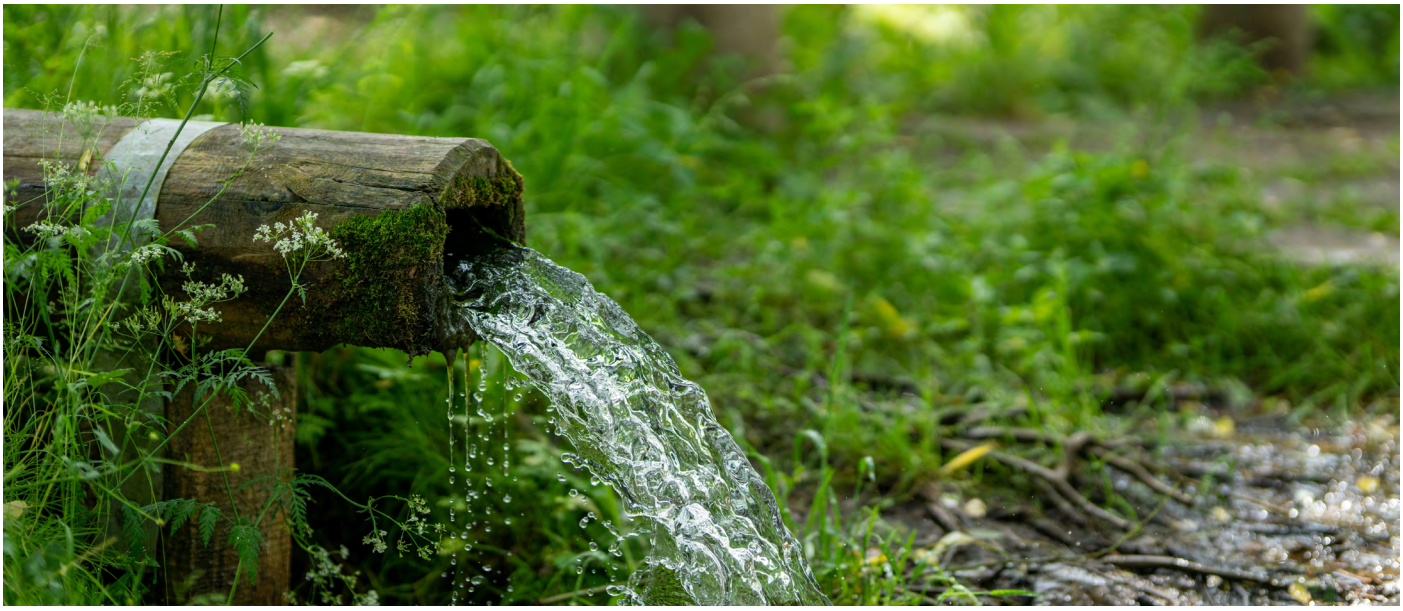
The National Institute for Standards and Technology in the USA, National Measurement Institute of Australia, Physikalisch-Technische Bundesanstalt of Germany, Health Sciences Authority in Singapore, and National Metrology Laboratory of the Philippines are amongst the organisations that currently produce reference materials for arsenic in water.

What should policy makers do?

To ensure the quality of arsenic analysis in groundwater, policymakers should:

1. establish and enforce standards and regulations
2. support National Metrology Institutes to develop reference materials and run proficiency testing schemes,
3. promote collaboration among relevant stakeholders
4. invest in capacity building for laboratory personnel
5. implement monitoring and evaluation mechanisms
6. raise public awareness
7. enforce compliance with regulatory requirements.

These actions are essential for mitigating the health risks associated with arsenic contamination, and safeguarding communities that rely on groundwater for drinking water.



Local example: Philippines

The health of the communities who live near active volcanoes in the Philippines is at risk due to arsenic contamination of their groundwater sources. Despite existing policies and regulations, arsenic contamination often goes undetected due to the lack of testing capabilities in some water testing laboratories.

In 2024, the National Metrology Laboratory of the Philippines filed a bill with the government, titled "An Act Establishing the National Measurement Institute of the Philippines."

- This will help the National Metrology Laboratory of the Philippines become an institute and expand its metrological capabilities and services.
- This bill seeks to modernize the laboratory's physical assets and operational procedures through developing and acquiring cutting-edge tools and facilities. In addition, it will strengthen and harmonize the nation's measurement system, aligning it to international best practices to support confidence in measurements for regulation, trade, and manufacturing.

In addition, we recommend that policymakers:

- Increase the number of accredited water testing laboratories in the country by encouraging small laboratories to participate in proficiency testing schemes and use reference materials produced by the National Metrology Laboratory of the Philippines.
- Introduce policy that will require each local government unit to have one to two testing laboratories capable of analysing arsenic in water. This will help the national government monitor the quality of water in secluded areas at least quarterly or monthly

References

1 Cauich-Kau, D., Rüde, T.R., Cardona-Benavides, A. et al. "Natural occurrence and controls of arsenic in groundwater in a semiarid basin in the Mexican Altiplano." Hydrogeol J 30, 2459–2477 (2022). https://doi.org/10.1007/s10040-022-02562-w

2 E.Shajia, M.Santosh,K.V.Sarath, et.al, "Arsenic contamination of groundwater: A global synopsis with focus on the Indian Peninsula", Geoscience Frontiers 2021; 12(101079). https://www.sciencedirect.com/science/article/pii/S1674987120302115#ab0015

3 Joel Podgorski and Michael Berg, "Global threat of arsenic in groundwater", Science 2020 May 22;368(6493):845-850. doi: 10.1126/science.aba1510

4 World Health Organization, "Guidelines for drinking-water quality: fourth edition incorporating the first and second addenda" (2022) https://www.who.int/publications/i/item/9789240045064

5 Kianoush Khosravi-Darani, "Arsenic Exposure via Contaminated Water and Food Sources", Water (2022) 14(12) 1884. https://www.mdpi.com/2073-4441/14/12/1884

6 Abhijnan Bhat, Tony O Hara, Furong Tian, and Baljit Singh, "Review of analytical techniques for arsenic detection and determination in drinking water", Environmental Science Advances 2023;2:171-195. doi: 10.1039/D2VA00218C

7 Abhijnan Bhat, Tony O Hara, Furong Tian, and Baljit Singh, "Review of analytical techniques for arsenic detection and determination in drinking water", Environmental Science Advances 2023;2:171-195. doi: 10.1039/D2VA00218C

8 The World Health Organization Report on Arsenic. https://www.who.int/news-room/fact-sheets/detail/arsenic