Presence, origin and impacts caused by Arsenic in water

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Global freshwater demand

• The global freshwater water demand is growing at exponential pace to cover needs for drinking water and agriculture.

• The global food demand, which is estimated to increase by 70% to feed the forecasted 9.3 billion people living on earth in 2050.

• Presently this freshwater demand in mostly covered by groundwater – which will remain the main share for global freshwater supply during the next decades.

• Thus providing drinking water to the growing population of the world through groundwater, including its treatment is a great challenge.

• Cross-border research and global knowledge supply is therefore needed to cater these challenges.
The Sustainable Development Goals – Transforming our World by 2030

• The Sustainable Development Goals (SDGs) – introduced in September 25, 2015 has been resolved to meet **17 Goals** has **169 Targets** and **230 Indicators** for progress within a span of **15 years**

• The SDGs most pertinent to Drinking Water revolves around SDG Target 6 “Clean Water and Sanitation

• This also links to the need for improved sustainable water and interconnected energy technologies and developments will contribute to improve the use of locally available environmentally-friendly climate-protecting renewable energy sources (Goal 7).
• Water is at the very core of sustainable development, critical for thriving people, planet and prosperity.
  – Water is needed for drinking and domestic purposes, for agricultural, industrial and energy production, and these uses are highly inter-linked, often competitive and they generate wastewater that may cause pollution.
  – Water is central to climate change, linking the climate system to the environmental and socio-economic systems; e.g. water scarcity and risk of flooding in others.

• Water is included in the 2030 Agenda as a dedicated Goal (SDG 6) to “ensure availability and sustainable management of water (and sanitation) for all”
Ensuring availability and sustainable management of water for all – calls for international cooperation
• KTH Royal Institute of Technology is one of the pioneers, who have initiated and pursued research on groundwater quality.

• From International perspectives, KTH plays a key role in pursuing high quality research on water resources.

• Since 1970’s KTH is actively involved with issues related to groundwater resources in different parts of the world, especially India and Bangladesh focussing on geogenic contamination.
  – Fluoride
  – Arsenic
  – Salinity
  – Radiogenic contaminants

• Groundwater contamination related to geothermal energy sources

• Our focus has been to understand the hydrogeological processes in the aquifers leading to the mobility of contaminants and developing mitigation strategies.
Implementation of Arsenic Mitigation for Drinking Water Safety

• Technology
  – Developing smart monitoring and better decision-making tools, application of locally adapted technologies are critical steps towards achieving the SDGs.

• Capacity-building
  – Capacity-building is closely linked to investments that support the use, adaptation, and transfer of new technologies, in addition to public awareness and the dissemination of best practices.

• Data, monitoring, and accountability frameworks (Open access)
  – The expansion of the water-related development agenda contained in the SDGs requires coordinated, fit-for-purpose monitoring systems that serve multiple actors, scales, and applications.

• Partnerships
  – Important to recognize existing alliances and build upon them to revitalize the Global Partnership for Sustainable Development.
Arsenic (As) is a metalloid and a member of the nitrogen family belonging to Group VA of the periodic table. It is an element which is tasteless and odorless.

• Arsenic ranks 20th in abundance in relation to the other elements.
Arсенic in groundwater - environmental geochemistry

- Predominant species:
  - Inorganic As\textsuperscript{V}
  - Inorganic As\textsuperscript{III}

- Oxidizing conditions and neutral to alkaline
  
  \[ \text{pH} \rightarrow \text{HAsO}_4^{2-} \]

- Reducing conditions and circum neutral
  
  \[ \text{pH} \rightarrow \text{H}_3\text{AsO}_3 \]

\[
\begin{align*}
\text{H}_3\text{AsO}_3 & \xrightarrow{-H^+} \text{H}_2\text{AsO}_3^- \\
\text{H}_2\text{AsO}_3^- & \xrightarrow{-H^+} \text{HAsO}_2^{2-} \\
\text{HAsO}_2^{2-} & \xrightarrow{-H^+} \text{AsO}_3^{3-}
\end{align*}
\]

\[
\begin{align*}
p\text{Ka}=9.1 & & p\text{Ka}=12.1 & & p\text{Ka}=13.4
\end{align*}
\]

\[
\begin{align*}
\text{H}_3\text{AsO}_4 & \xrightarrow{-H^+} \text{H}_2\text{AsO}_4^- \\
\text{H}_2\text{AsO}_4^- & \xrightarrow{-H^+} \text{HAsO}_3^{2-} \\
\text{HAsO}_3^{2-} & \xrightarrow{-H^+} \text{AsO}_4^{3-}
\end{align*}
\]

\[
\begin{align*}
p\text{Ka}=2.1 & & p\text{Ka}=6.7 & & p\text{Ka}=11.2
\end{align*}
\]
Elevated As in groundwater at a global scale
Global Scenario of Elevated Arsenic in groundwater - Latin America

**Estimates of population exposed (number of persons)**

- Argentina: 0
- Chile (before 1970s): 500,000
- Mexico: 1.2 million
- Peru: 450,000
- Bolivia: 250,000
- Ecuador: >200,000
- Colombia: unknown, at least some thousands
- Nicaragua: unknown
- Costa Rica: unknown
- El Salvador: unknown
- Guatemala: unknown

**Estimates of population exposed (% of national population)**

- Argentina: 0%
- Chile (before 1970s): 3.0–5.1%
- Mexico: 0.4%
- Peru: 0.9%
- Bolivia: >2.3%
- Ecuador: unknown
- Colombia: unknown
- Nicaragua: unknown
- Costa Rica: unknown
- El Salvador: unknown
- Guatemala: unknown
Exposure Risk in Latin America
Digital Water Platform
ASMITAS for scaling-up access to safe water

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Arsenic remediation of drinking water
Sustainable Arsenic Mitigation (SASMIT)

- Drinking water supply in Bangladesh mostly (> 90%) depends on groundwater
- Most widely accepted option is manually operated suction mode hand tubewell
- More than 90% of 10 million tubewells are privately owned and installed by the local tubewell drillers
- SASMIT is a community based and cost efficient strategy for targeting safe groundwater for installation of safe drinking water tubewells
- Optimized on the basis of local knowledge and technique
Mitigation option failure

- As-safe Tubewell
- Rain Water Harvester (RWH)
- Pond Sand Filter (PSF)
- Filter to remove bacteria from Arsenic safe surface water (Bishudhya Filter)
- Arsenic Removal Filter (ARF)
Idea that worked: **Drillers approach**
Sediment color

![Box plot showing sediment color distribution](image)

- Black
- White
- Off-white
- Red
Assessment of hydrogeological conditions
Knowledge base developed for identifying the safe aquifers

- Test boring and sediment sampling at 15 locations to the depth of 250 m (800 ft), no. of samples = 2240
SASMIT Innovation: Sediment Color Tool

Risk of arsenic in groundwater

High | Low

Redox status

Highly reduced | Less reduced

BLACK | WHITE | OFF-WHITE | RED
Transformation: ASMITAS
Methodology

Data Connectivity to upload Spectral Signatures

Low cost spectral camera with Limited compute capability

Data Connectivity to access detailed analysis

SaaS portal accessed via Mobile App

Cloud based Solution

Colour Matching tool

Reference Libraries

Analytics Engine

Spectra Profiles - Sediments
ASMITAS Potential

- Safe ground water mapping
- Driller Mapping & Project Mapping
- Safe Aquifer mapping based on SASMIT principles
- Data visualization for whole project
- Accelerate the path to achieve SDG goals
ASMITAS Potential

• Transparent decision support and enhanced accountability
• Simplify the decision making regarding site selection by the local decision makers
Thank you!