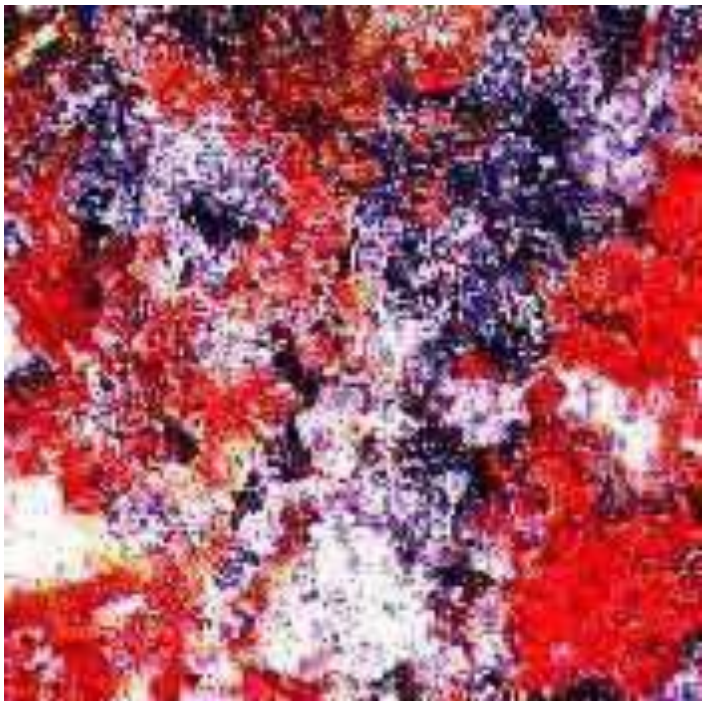
Experiment 10
Determination of Arsenic in Water



Introduction:

Presence of elevated levels of arsenic in groundwater (especially from shallow aquifer) has become a major concern in Bangladesh. Arsenic pollution of groundwater is particularly challenging in Bangladesh since tubewell water extracted from shallow aquifers is the major source of drinking water for most of its population. The rural water supply is almost entirely based on groundwater supply through use of hand pump tubewells; the urban water' supply is also heavily dependent on groundwater. In Bangladesh, the arsenic in groundwater is of geologic origin and is probably only apparent now because it is only the last 20 - 30 years that groundwater has been extensively used for drinking in rural areas.

Weathering of arsenic-rich base metal sulphides in the upstream of the Ganges basin appears to be a major source of arsenic-rich iron oxyhydroxides in the sediments of Bangladesh. Use of phosphate fertilizer can potentially enhance release of arsenic as a result of replacement of arsenic by phosphate ions on the adsorption sites of iron oxyhydroxides. Natural and anthropogenic processes that may lead to release/mobilization of arsenic in the subsurface are being investigated.

Arsenic occurs in water in several different forms. Depending upon the pH and the redox potential, E_h. Some of the most important compounds and species are shown in Table 1.

Table 1: Arsenic compounds and species and their environmental and toxicological importance in water

Compounds	Example	Environmental Significance/ Dominant pH region	Toxicity
Arsine	As3.	Minor importance	Most toxic As
Elemental Arsenic	As	Minor importance	Least toxic As
Trivalent Arsenic	As(III)	Anaerobic	10 more As(V)
Arsenite, Inorganic	H_3As0_3, $H_2As0_3^{1-}$, $HAs0_3^{2-}$., $As0_3^{3-}$.	pH = 0-9 pH = 10-12 pH = 13 pH = 14	
Methylated As(III) Organo-As(III)		Minor importance	Less toxic than As(III)
Pentavalent arsenic	As(V)	Aerobic	10 times less As(III).
Arsenate, Inorganic	H_3As0_4, H_2As0^{1-}, $HAs0_4^{2-}$., $As0_4^{3-}$.	pH = 0-2 pH = 3-6 pH = 7-11 pH = 12-14	
Methylated As(V) Organo-As(V)		Minor importance	Less than As(V)

In groundwater, arsenic primarily exists as inorganic arsenic. Inorganic trivalent arsenic, [As(III)] or arsenite is the dominant form in reducing environment; while inorganic pentavalent arsenic [As(V)] or arsenate is the dominant form in oxidizing or aerobic environment. In groundwater environment where the conditions are mostly reducing, a

significant part of the arsenic exists as As(III).

Environmental significance:

Arsenic is a major **environmental** pollutant and exposure occurs through **environmental**, occupational and medicinal sources. Airborne exposure is small except in polluted locations. Food exposure can be significant but, particularly in fish and shellfish, it is mostly in organic forms that are relatively nontoxic. Drinking water remains the most significant source worldwide, and large numbers of people are subject to serious exposure from this source. Toxicity consists mostly of neuropathy, skin lesions, vascular damage, and carcinogenesis. Vascular lesions are the result of endarteritis (blackfoot disease). This appears to be more prevalent in developing rather than developed countries and may be related to nutritional deficiencies. Skin cancer is the most clearly associated malignancy related to arsenic exposure from drinking water; however, bladder, lung, liver, and kidney tumors also appear to be related. There is no particular remedial action for chronic **arsenic** poisoning. Low socioeconomic status and malnutrition may increase the risk of chronic toxicity.

Guideline:

According to BECR 2023, drinking water standard for arsenic in Bangladesh is 50 μg/L(or 0.05 mg/L). The WHO guideline value for arsenic in drinking water is 10μg/Land the USEPA is also planning to revise its standard from 50 μg/L to 10μg/L.

Analytical Methods for Measuring Arsenic:

The most commonly used method for detection of arsenic concentration water may be categorized as follows:

1. Inductively coupled plasma (ICP) method
2. Hydride generation atomic absorption spectrophotometric method
3. Graphite furnace atomic absorption spectrophotometric method
4. Hydride generation-scraper-spectrophotometric (SDOC) method
5. Hydride generation-scraper-indicator paper-field kit

The first three methods involve high-cost equipment and provide more accuracy and lower detection limit (minimum detection limit, MDL = 1 μg/L). The last two methods are relatively low cost methods but accuracy of determination is less.

Inductively coupled plasma (ICP) method

An ICP source consists of a flowing stream of argon gas ionized by applied radio frequency field typically oscillating at 27.1 MHz. The water sample is atomized at temperature about 6000 to 8000.^{0} K. The light emitted from ICP Hydride generation atomic absorption spectrophotometric method is focused on entrance slit and using radio frequency determines absorbance of arsenic.

Hydride generation atomic absorption spectrophotometric method

In this method arsenic is reduced to gaseous arsine in a reaction vessel. The method is two types: i) manual hydride generation and ii) continuous hydride generation. In manual method zinc is added to speed the reaction whereas continuous in continuous hydride generation no zinc is needed. In continues measurement hydride generator a peristaltic pump is used to meter and mix reagents and a gas-liquid separator unit uses flow of argon to strip out hydrogen and arsine gas.

Hydride generation-sera per-spectrophotometric (SDDC) method

Minimum detectable quantity for this method is 1 micro gram As. This method essentially involves: conversion (reduction) of all arsenic in water into As(III) and generation of arsine gas in the form of arsenic hydride (AsH3). Absorbance of red-coloured complex produced by passing of arsine gas through a solution of silver diethyl-dithiocarbamate (SODC) is

measured in a spectrophotometer at 535 nm wavelength.

Hydride generation-scraper-indicator paper-field kit
A simple and reasonably accurate method for arsenic measurement Similar to SOOC method all arsenic in water is converted to As(III) and generates arsine gas which is then passes through a filter paper soaked in mercuric bromide.

***Laboratory Measurement of Arsenic by Arsenic Tool kit Method*:**
In the class arsenic measurement by arsenic tool kits will be conducted. The kit involves the generation of arsine (AsH_3) from inorganic arsenic species by reduction with Zn and HCl. The arsine then reacts with a test strip containing $HgBr_2$ to produce a color that is compared with a color scale for quantitation.

Apparatus:

1. Arsenic toolkits

Procedure:

1. Add reagent to Reaction Bottle and shake vigorously.
2. Insert the strip into the turret and close it. Let it sit 10 minutes.
3. Select the As concentration on the chart that matched the color of the test strip most closely. The reference chart provided with the kit displays the yellow to brown range of colors expected for As concentrations of 0, 10, 25, 50, 100, 200, 300, 500, and 1000 μg/L.

Assignment:

1. Discuss possible sources of arsenic in ground water.
2. Does the toxicity of arsenic contaminated groundwater depend on arsenic speciation?