

## Determination of the Arsenic Concentration in Water Near Hinthada University by AAS Method

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### Abstract

Arsenic can be found in sea water, rivers and ground water. Elementary arsenic normally does not react with water in absence of air. Drinking water with arsenic at safe-level is important for people. Five water samples were collected from the Hinthada town including Hithada University campus. Arsenic concentration in water samples are determined by AAS method.

**Key Words:** Atomic absorption spectroscopy (AAS), arsenic concentration, water samples

### Introduction

Arsenic is an essential compound for many animal species, because it plays a role in protein synthesis. It is unclear whether arsenic is a dietary mineral for humans. Arsenic toxicity is another important character. The boundary concentration of arsenic is 2-46 ppm for freshwater algae. The LC<sub>50</sub> value for *Daphnia Magna* is 7.4 ppm, and for the American oyster which is 7.5 ppm. These values encompass a time period of 48 hours. The chronic toxicity value for a time period of three weeks is 0.5 ppm for the large cladoceran. For rates an LC<sub>50</sub> value of 20 mg/kg body mass was established. This is the value for the carcinogenic arsenic (III) oxide compound. This compound also blocks enzymatic processes, increasing its toxicity. In mice, hamsters and rats, the compound was embryo toxic and teratogenic.

Naturally, only one stable arsenic isotope exists. Currently 19 other instable isotopes have been discovered. Arsenic related illness is usually caused by consumption of contaminated drinking water. In the old days it was applied as a poison, because symptoms of arsenic poisoning resemble cholera symptoms, and therefore the intentional factor was shaded.

Arsenic appears to be essential for some plant and animal species. A possible safe dose for humans was calculated. If arsenic is a dietary mineral, this dose would be 15-25 µg. This amount could be absorbed from food without any trouble. The total amount of arsenic in a human body is about 0.5-15 mg. Many arsenic compounds are absorbed 60-90%, but they are also easily excreted. Humans can develop resistance to certain arsenic concentrations. Shortly after absorption arsenic can be found in liver, spleen, lungs and digestive tract. Most arsenic is excreted, and residues may be found in skin, hair, nails, legs and teeth. Under conditions of prolonged exposure, many organs may be damaged, skin pigmentation may occur, hair may fall out and nail growth may stop.

Toxicity differs among the various arsenic compounds, for example, monomethyl arsenic acid and inorganic arsenide have a higher toxicity level than arsenic choline. Acute toxicity is generally higher for inorganic arsenic compounds than for organic arsenic compounds. Oral intake of more than 100 mg is lethal. The lethal dose of arsenic trioxide is 10-180 mg, and for arsenide this is 70-210 mg. The mechanism of toxicity is binding and blocking sulphur enzymes. Symptoms of acute arsenic poisoning are nausea, vomiting,

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diarrhea, cyanosis, cardiac arrhythmia, confusion and hallucinations. Symptoms of chronic arsenic poisoning are less specific. These include depression, numbness, sleeping disorders and headaches.

Arsenic related health effects are usually not acute, but mostly encompass cancer, mainly skin cancer. Arsenic may cause low birth weight and spontaneous abortion. Arsenic in drinking water is an issue of global importance; therefore the legal limit was decreased to  $10\mu\text{g/L}$ .

### Materials and Methods

Atomic Absorption Spectroscopy (AAS) is a spectroanalytical procedure for the qualitative and quantitative determination of chemical elements employing the absorption of optical radiation (light) by free atoms in the gaseous state. AAS can be used to determine over 70 different elements in solution or directly in solid samples. ([www.en.wikipedia.org/wiki/Atomic\\_absorption\\_spectroscopy](http://www.en.wikipedia.org/wiki/Atomic_absorption_spectroscopy))

#### Principle of atomic absorption spectroscopy

The technique makes use of absorption spectrometry to assess the concentration of an analyte in a sample. It requires standards with known analyte content to establish the relation between the measured absorbance and the analyte concentration and relies therefore on Beer-Lambert Law. In short, the electrons of the atoms in the atomizer can be promoted to higher orbital (excited state) for a short period of time (nanoseconds) by absorbing a defined quantity of energy (radiation of a given wavelength). This amount of energy, i.e., wavelength, is specific to a particular electron transition in a particular element. In general, each wavelength corresponds to only one element, and the width of an absorption line is only of the order of a few picometers (pm), which gives the technique its elemental selectivity.

In order to analyze a sample for its atomic constituents, it has to be atomized. The atomizers most commonly used nowadays are flames and electrothermal (graphite tube) atomizers. The atoms should then be irradiated by optical radiation, and the radiation source could be an element-specific line radiation source or a continuum radiation source. The radiation then passes through a monochromator in order to separate the element-specific radiation from any other radiation emitted by the radiation source, which is finally measured by a detector. Atomic absorption spectrometer block diagram is shown in Figure 1.

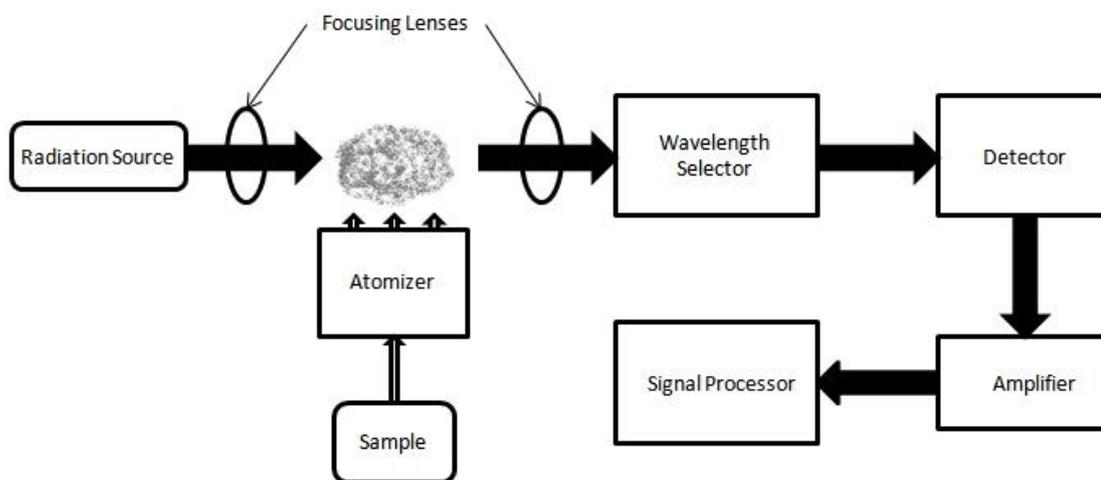


Figure 1 Atomic absorption spectrometer block diagram

## Atomizers

Although other atomizers, such as heated quartz tubes, might be used for special purposes, the atomizers most commonly used nowadays are (spectroscopic) flames and electrothermal (graphite tube) atomizers.

### Flame Atomizers

The oldest and most commonly used atomizers in AAS are flames, principally the air-acetylene flame with a temperature of about 2300°C and the nitrous oxide (N<sub>2</sub>O)-acetylene flame with a temperature of about 2700°C. Liquid or dissolved samples are typically used with flame atomizers. The sample solution is aspirated by a pneumatic nebulizer, transformed into an aerosol, which is introduced into a spray chamber, where it is mixed with the flame gases and conditioned in a way that only the finest aerosol droplets (< 10 µm) enter the flame. This conditioning process is responsible that only about 5% of the aspirated sample solution reaches the flame, but it also guarantees a relatively high freedom from interference.

On top of the spray chamber is a burner head that produces a flame that is laterally long (usually 5–10 cm) and only a few mm deep. The radiation beam passes through this flame at its longest axis, and the flame gas flow-rates may be adjusted to produce the highest concentration of free atoms. The burner height may also be adjusted, so that the radiation beam passes through the zone of highest atom cloud density in the flame, resulting in the highest sensitivity.

The processes in a flame include the following stages:

- Desolvation (drying) – the solvent is evaporated and the dry sample nano-particles remain;
- Vaporization (transfer to the gaseous phase) – the solid particles are converted into gaseous molecules;
- Atomization – the molecules are dissociated into free atoms;
- Ionization – depending on the ionization potential of the analyte atoms and the energy available in a particular flame, atoms might be in part converted to gaseous ions.

### Electrothermal Atomizers

Electrothermal AAS (ET AAS) using graphite tube atomizer was pioneered by Boris V. L'vov at the Saint Petersburg Polytechnical Institute, Russia. With this technique liquid/dissolved, solid and gaseous samples may be analyzed directly. A measured volume (typically 10–50 µL) or a weighed mass (typically around 1 mg) of a solid sample are introduced into the graphite tube and subject to a temperature program. This typically consists of stages, such as:

- Drying – the solvent is evaporated
- Pyrolysis – the majority of the matrix constituents is removed
- Atomization – the analyte element is released to the gaseous phase
- Cleaning – eventual residues in the graphite tube are removed at high temperature.

The graphite tubes are heated via their ohmic resistance using a low-voltage high-current power supply; the temperature in the individual stages can be controlled very closely, and temperature ramps between the individual stages facilitate separation of sample

components. Tubes may be heated transversely or longitudinally, where the former ones have the advantage of a more homogeneous temperature distribution over their length. The major components of this concept are:

- Atomization of the sample from a graphite platform inserted into the graphite tube (L'vov platform) instead of from the tube wall in order to delay atomization until the gas phase in the atomizer has reached a stable temperature;
- Use of a chemical modifier in order to stabilize the analyte to a pyrolysis temperature that is sufficient to remove the majority of the matrix components;
- Integration of the absorbance over the time of the transient absorption signal instead of using peak height absorbance for quantification.

### **Radiation Sources**

We need to be distinguished between line source AAS (LS AAS) and continuum source AAS (CS AAS). In classical LS AAS, the high spectral resolution required for AAS measurements is provided by the radiation source itself that emits the spectrum of the analyte in the form of lines that are narrower than the absorption lines. Continuum sources, such as deuterium lamps, are only used for background correction purposes. The advantage of this technique is that only a medium-resolution monochromator is necessary for measuring AAS; however, it has the disadvantage that usually a separate lamp is required for each element that has to be determined. In CS AAS, in contrast, a single lamp, emitting a continuum spectrum over the entire spectral range of interest is used for all elements.

### **Continuum Sources**

When a continuum radiation source is used for AAS, it is necessary to use a high-resolution monochromator. In addition it is necessary that the lamp emits radiation of intensity at least an order of magnitude above that of a typical HCL over the entire wavelength range from 190 nm to 900 nm. A special high-pressure xenon short arc lamp, operating in a hot-spot mode has been developed to fulfill these requirements.

In atomic absorption, there are two methods of adding thermal energy to a sample. A graphite furnace AAS uses a graphite tube with a strong electric current to heat the sample. In flame AAS, a sample aspirate is aspirated into a flame using a nebulizer. The flame is lined up in a beam of light of the appropriate wavelength. The flame (thermal energy) causes the atom to undergo a transition from the ground state to the first excited state. When the atoms make their transition, they absorb some of the light from the beam. The more concentrated the solution, the more light energy is absorbed.

The light beam is generated by lamp that is specific for a target metal. The lamp must be perfectly aligned so the beam crosses the hottest part of the flame. The light that passes through the flame is received by the monochromator, which is set to accept and transmit radiation at the specified wavelength and travels into the detector. The detector measures the intensity of the beam of light. When some of the light is absorbed by metal, the beam's intensity is reduced. The detector records that reduction as absorption. That absorption is shown on output device by the data system.

The concentrations of metals can be found in a sample running a series of calibration standards through the instrument. The instrument will record the absorption generated by a given concentration. By plotting the absorption versus the concentrations of the standards, a calibration curve can be plotted. The absorption for a sample solution is looked at and the calibration curves are used to determine the concentration. Figure 2 shows an idealized and deviation of response curve.

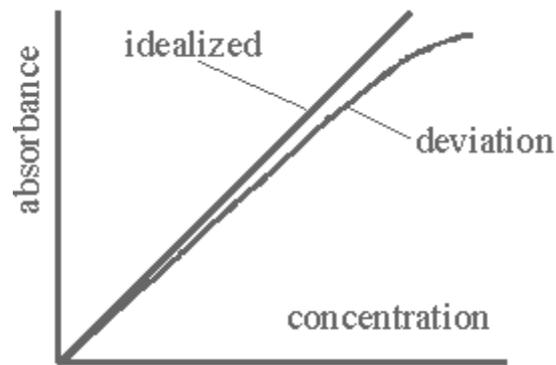


Figure 2 An idealized and deviation of response curve

### Results

The results of arsenic concentrations in water samples are shown in the following Table.

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### Discussion and Conclusion

To determine the arsenic concentration, the water samples are collected. Water sample 1 is collected from Hinthada University. Water sample 2 is collected from Chaung Phya. Water sample 3 is collected from Natmaw. Water sample 4 is collected from Pabedan Ward, the depth is 42 feet. Water sample 5 is collected from Pabedan Ward, the depth is 95

feet. Water sample 6 is collected from Pabedan Ward, the depth is 280 feet. The results of arsenic concentrations are as follows

S-1	4.256 mg/L
S-2	5.012 mg/L
S-3	5.162 mg/L
S-4	5.235 mg/L
S-5	5.872 mg/L
S-6	5.923 mg/L

The legal limit for arsenic in water applied by the World Health Organization (WHO) is 10 µg/L. Compared to the legal limit of WHO, the arsenic presence in these samples are too high. Arsenic in drinking water causes bladder, lung and skin cancer, and may cause kidney and liver cancer. The study also showed that arsenic harms the central and peripheral nervous systems, as well as heart and blood vessels, and causes serious skin problems. It also may cause birth defects and reproductive problems.

The arsenic present in water near Hinthada University is 500 times higher than the WHO legal limit. Therefore, the water near Hinthada University is used to bathe and wash only. The effect of arsenic can be reduced by water purification technologies. Arsenic removal from water can be carried out in different ways. Options include ion exchange, membrane filtration, and iron and aluminum coagulation. Drinking water mainly contains inorganic arsenic (arsenic or arsenate), therefore determining total arsenic concentration suffices. Distinguishing between different types of arsenic is irrelevant.

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