

# Analysis of heavy metals in water samples- A study by Atomic Absorption spectrophotometry

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**ABSTRACT:** Pollution is a major cause of concern affecting not only the nature but also the food we consume. In a recent study high concentrations of heavy metals like arsenic, nickel, cadmium and lead were found in aquatic life (fish samples obtained from various outlets in Hyderabad and Secunderabad). The concentration of heavy metals depend on the fish species. Presence of heavy metals in these fish is an issue of pollution of water bodies, which is of major concern. Hence there is a need to know the concentrations of heavy metals in water. In the present study an attempt was made to analyse the concentrations of arsenic, nickel, cadmium and lead by atomic absorption spectrophotometry. Water naturally contains a few heavy metals but their concentrations are low and the high concentrations are due to pollution.

**Key words:** Arsenic, nickel, cadmium, lead, atomic absorption spectrophotometry.

## 1. INTRODUCTION:

The availability of good quality water is very essential for preventing diseases. Natural water contains some impurities whose nature and amount vary with source of water. Metals for example, are introduced into the water system through many ways such as weathering of rocks and leaching of soils, dissolution of aerosol particles from the atmosphere and from several human activities, including mining, processing and the use of metal based materials(1). Metals after entering the water may be taken up by fauna and flora and eventually get accumulated in marine organisms that are consumed by humans. The increased use of metal-based fertilizer in agricultural revolution of the government could result in continued rise in concentration of metal pollutions in fresh water reservoir due to the water run-off.

The aquatic ecosystem is upset by human activities, resulting in pollution which is manifested dramatically as offensive taste, odour, colour. The presence of heavy metals in the water bodies is a cause of concern due to their toxic nature. These dissolved metals have adverse impacts on aquatic life. Most heavy metals such as nickel, arsenic, cadmium, lead, copper, chromium, Thallium etc. are cations which carry a positive charge(2). Heavy metals are part of the earth's crust and cannot be destroyed. They enter into human, animal and plant via drinking water or air. Copper, selenium and zinc are essential for the metabolism of the human body, but at higher concentrations are toxic. Heavy metal poisoning occurs via the food chain. Distribution of heavy metals in water, sediments, plants, and fish play a key role in detecting sources of heavy metal pollution in aquatic ecosystem.

## 2. METHODOLOGY

Atomic absorption spectrometer entails the determination of the element at its line centre by using a narrow line source emitting the given resonance line whose emission line profile is less than absorption line profile of its analyte in flame. The flame gases are treated as a medium containing free unexcited atoms capable of absorbing radiation from an external source. When the radiation corresponds exactly equal to the energy required for the transition of the test element from the ground electronic state to an upper excited electronic state. Unabsorbed radiation passes through a monochromator that isolates the exciting spectral line and into a photodetector. Absorption is measured by the difference in transmitted signal in the presence of absorbance of the test signal.

A compressor and a cylinder fitted with the acetylene gas was used. The pressure was set at 1 psi. Hollow cathode lamp of the respective element was used each time for the analysis of arsenic, nickel, cadmium and lead respectively.

The atom of an element has a nucleus surrounded by electrons (which rotate around the nucleus) characteristic of that element. When light of right wavelength impinges on the free ground state atom, the atom absorbs light and enters the excited state in a process known as atomic absorption. In atomic absorption measurement, the amount of light at the resonant wavelength is absorbed as light passes through the cloud of atoms. As the number of atoms in the light path increase the amount of light absorbed increases. This capability of an atom to absorb very specific wavelength of light is utilized in atomic absorption spectrophotometry. The light used to excite the atom is produced by hollow cathode lamp (the cathode is the respective element which is to be estimated). The atom cloud required for atomic absorption measurements is produced by supplying enough thermal energy to the sample to dissociate the chemical compounds into free atoms. Solution of the sample is aspirated into a flame aligned in the light beam. The atoms absorb light at the analytical wavelength from the source lamp. Absorbance follows a linear relationship with concentration as shown by the Beers law.

According to Beers law,  $A = abc$ , where  $A$  is the absorbance,  $a$  is the absorption coefficient, a constant, which is characteristic of the absorbing species at a wavelength,  $b$  is the length of the light path intercepted by the absorption species in the absorption cell and  $c$  is the concentration of the absorbing species (3-4). The above equation states that absorbance is directly proportional to the concentration of the absorbing species. This direct proportionality between absorbance and concentration is observed in atomic absorption. The absorbance is plotted against concentration a calibration relationship similar to figure-1 is established. After such a calibration is established the absorbance of the solutions of unknown concentration is measured from the calibration plot. The light source is the hollow cathode lamp which consists of a quartz envelope with two electrodes. The cathode is cup shaped made of the specified element. The lamp is filled with low pressure argon gas. A slow discharge is produced by applying 100 to 200 volts, positive ions from the inert gas bombard the cathode removing the metal atoms by sputtering. These atoms excite and emit characteristic radiation(5).

Atomisation is done by flame atomization. In flame atomization fuel and oxidants are fed into the mixing chamber, where after a series of baffles the sample is aspirated by an air jet. The sample is digested in an automatic microwave digester. The sample is drawn by the nebulizer with a stream of nitrogen and is converted into a mist and mixed with acetylene fuel gas. This is now fed to the burner to give the laminar flame. The burning sample produces the gaseous atoms of the sample which absorb a part of the radiation proportional to the concentration of the analyte element. The unabsorbed radiation falls on the monochromator which selects the wavelength characteristic of the analyte sample. The instrument can be calibrated to read absorbance or concentration.

## RESULTS AND DISCUSSION:

The procedure outlined describes an extremely sensitive and accurate method for the determination of arsenic, nickel, cadmium and lead in the water samples down to 1.0ppb in solution. The samples were taken and the metals were reduced to the elemental state and aerated from solution. The vapours passed through a quartz absorption cell of the atomic absorption spectrophotometer where the concentrations were measured. The procedure is free from interferences due to organic matter or other volatile constituents of the sample(6-7).

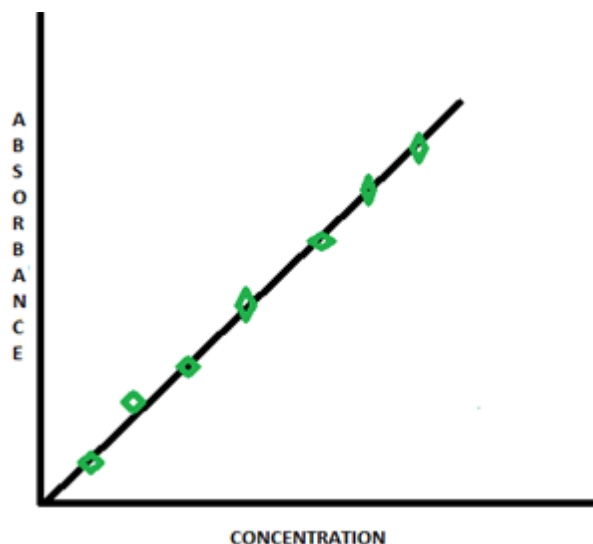
Atomic absorption spectrophotometer is used to determine the concentrations of Arsenic, nickel, cadmium and lead present in the water sample by the measurement of absorption of the characteristic radiation by the atomic vapour of the respective elements.

It is based on the principle that when radiation characteristic of a particular element passes through an atomic vapour of the same element absorption of radiation occurs in proportion to concentration of atoms in the light path. The amount of light absorbed is measured and a quantitative determination of the amount of analyte element present can be made. Selection of the light sources and

wavelength was done allowing specific quantitative determination of the individual elements in the presence of others. Accurate determinations were done with this technique with more speed, ease and precision(8-9).

A calibration graph is obtained by plotting absorbance Vs. concentration (FIGURE-1)

**FIGURE-1**



#### 4. CONCLUSION:

The amount of light absorbed is measured and a quantitative determination of the amount of analyte element present can be made. Selection of the light sources and wavelength was done allowing specific quantitative determination of the individual elements in the presence of others(10). Accurate determinations were done with this technique with more speed, ease and precision.

#### 4. Acknowledgments:

The authors are thankful to the Chairman, Joint secretary and Principal of G.Narayanamma Institute of Technology and Science for providing all the facilities to carry on the research work.

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