

Graphite Furnace Atomic Absorption Spectrometry Studies of Amount of Metallic elements in Water Samples of Bundelkhand Region in Year 2013



Chemistry

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ABSTRACT

From the Bundelkhand region 40 water samples collected in year 2013. Graphite Furnace Atomic Absorption Spectrometry (GFAAS) technique was used for analysis of water samples for 35 metals that concern us because of occupational or residential exposure. Out of 35 metals 23 metals are the heavy elements or "heavy metals" are good for health in small quantities and cause health problem when present in high amount. And the results were discussed in term of presence of particular metal with time and region.

Introduction

Water covers 71% of the Earth's surface. Water is the most vital element and is crucial for the survival of all living organisms. Economic growth and development of any country are all highly influenced by water. Availability and the quality of surface and ground water is highly responsive to the monsoon, climate and upstream withdrawal for consumptive and non consumptive uses. The main pollutants of surface water are untreated industrial effluents, municipal waste, chemical fertilizers, pesticides, oil & libel spillage in the coastal area from the operation of sea & river ports.

In the present study we have collected water samples from 40 places in Bundelkhand region of India in year 2013 and analyzed for various heavy metals- Arsenic, copper, mercury, lead and cadmium [1-4]. The samples consist of surface water, deep-water, factory outlets from the Matatila, Orcha, Kalpi and Jhansi. Heavy metal toxicity can result in damaged or reduced mental and central nervous function, low energy levels and damage to blood composition, lungs, kidneys, liver and other vital organs.

For some heavy metals, toxic levels can be just above the background concentrations naturally found in nature [5]. Therefore, it is important for us to inform ourselves about the heavy metals and to take protective measures against excessive exposure. In most parts of India, heavy metal toxicity is an uncommon medical condition; however, it is a clinically significant condition when it does occur. If unrecognized or inappropriately treated, toxicity can result in significant illness and reduced quality of life.

Materials and Method

Instrument used: Graphite Furnace Atomic Absorption Spectrometry

Graphite furnace atomic absorption (GFAA) spectrometry is a highly sensitive spectroscopic technique that provides excellent detection limits for measuring concentrations of metals in aqueous and solid samples [6,7]. GFAA has been used primarily in the field for the analysis of metals in water.

System Components

GFAA spectrometry instruments have the following basic features:

1. A source of light (lamp) that emits resonance line radiation.
2. An atomization chamber (graphite tube) in which the sample is vaporized.
3. A monochromatic for selecting only one of the characteristic wavelengths (visible or ultraviolet) of the element of interest.
4. A detector, generally a photomultiplier tube (light detector that are useful in low intensity application), that measures the amount of absorption.
5. A signal processor- computer system (strip chart recorder, digital display, meter, or printer).

Mode of operation

Most currently available GFAAs are fully controlled from a personal computer. Aqueous samples was acidified (with nitric

acid) to pH of 2.0 or less. Discoloration in a sample may indicate that metals are present in the sample. After the instrument has warmed up and has been calibrated, a small aliquot (usually less than 100 micro liters and typically 20 micro liters is placed, either manually or through an automated sampler, into the opening in graphite tube; the amount of light energy absorbed in the vapor is proportional to atomic concentrations. Analysis of each sample takes from 1 to 5minutes, and the results for a sample are the averaged of triplicate analysis.

Graphite tubes was changed after every 200 to 800 burns because they become pitted and produce data that are only poorly reproducible, and results in a loss of sensitivity. The samples were diluted if the absorbance is outside the calibration range. GFAA has a smaller linear concentration range than flame AA or inductively coupled plasma (ICP) spectrometry. Necessary precautions were taken to avoid contamination of the samples.

Calibration

Continued calibration of the instrument is a component of overall quality control plan and should be performed by analyzing one mid-concentration standard after every 10 analyses. The relative percent difference (RPD) between the initial calibration and the continuing calibration should be less than 15 percent.

Results and Discussion

The present study has been conducted on 40 water samples collected from Bundelkhand region. The water samples consist of surface water, deep water, factory outlets from the Matatila, Orcha, Kalpi, and Jhansi. The collected samples were analyzed with the help of Graphite Furnace Atomic Absorption Spectrometry. There are 35 metals that concern us because of occupational or residential exposure; 23 of these are the heavy elements or "heavy metals": antimony, arsenic, bismuth, cadmium, cerium, chromium, cobalt, copper, gallium, gold, iron, lead, manganese, mercury, nickel, platinum, silver, tellurium, thallium, tin, uranium, vanadium, and zinc. Interestingly, small's amounts of these elements are common in our environment and diet and are actually necessary for good health, but large amounts of any of them may cause acute or chronic toxicity (poisoning).

Definition of heavy metals

Heavy metals are chemical elements with a specific gravity that is at least five times the specific gravity of water. The specific gravity of water is one at 4 degree C (39degree F) [8-10]. Some well known toxic metallic elements with a specific gravity that is 5 or more times that of water are Arsenic, 5.7; cadmium, 8.65; iron, 7.9; lead, 11.34; and Mercury, 13.546.

Beneficial heavy metals

In small quantities, certain heavy metals are nutritionally essential for a healthy life. Some of these are referred to as the trace elements (e.g. Iron, Copper, Manganese and Zinc). These elements or some forms of them are commonly found in food-stuffs, in fruits and vegetables and in commercially available multivitamin products. Diagnostic medical applications include direct injection of Gallium during Radiological procedures, dosing with chromium in parental nutrition mixtures and the use of lead as a radiation shield around x-ray equipments. Heavy

metals are also common in industrial applications such as in the manufacture of pesticides, batteries, alloys, and electroplated metal parts, textile dyes, steel and so forth.

Toxic heavy metals

Heavy metals become toxic when they are not metabolized by the body and accumulate in the soft tissues. Heavy metals may enter the human body through food, water, air, or absorption through the skin when they come in contact with humans in agriculture and in manufacturing, pharmaceutical, industrial or residential setting.

Commonly Encountered Heavy Metals

Arsenic, Lead, Mercury, Cadmium, Copper

Arsenic

Arsenic is the most common cause of acute heavy metal poisoning in adults. Arsenic is released into the environment by the smelting process of copper, zinc, and lead, as well as by the manufacturing of chemicals and glasses. Arsenic gas is a common byproduct produced by the manufacturing of pesticides that contain arsenic. Arsenic may be also be found in water supplies worldwide, leading to exposure of shellfish, cod, and haddock. Other sources are paints, rat poisoning, fungicides, and wood preservatives. Target organs are the blood, kidneys, and central nervous, digestive, and skin systems.

Lead

Lead accounts for most of the cases of pediatric heavy metal poisoning. It is a very soft metal and was used in pipes, drains, and soldering materials for many years. Millions of homes built before 1940 still contain lead (e.g. in painted surfaces), leading to chronic exposure from weathering, flaking, chalking, and dust. Every year, industry produces about 2.5 million tons of lead throughout the world. Most of this lead is used for batteries. The remainder is used for cable coverings, plumbing, ammunition, and fuel additives. Other uses are as paint pigments and in PVC plastics, x-ray shielding, crystal glass production, pencils and pesticides. Target organs are the bones, brain, blood, kidneys and thyroid gland.

Mercury

Mercury is generated naturally in the environment from the degassing of the earth's crust, from volcanic emissions. It exists in three forms: elemental mercury and organic and inorganic mercury. Mining operations, chloral kali plants and paper industries are significant producers of mercury. Atmospheric mercury is dispersed across the globe by winds and returns to the earth in rainfall, accumulation in aquatic food chains and fish in lakes. Mercury compounds were added to paint as a fungicide until 1990. These compounds are now banned; however, old paint supplies and surfaces painted with these old supplies still exist. Mercury continues to be used in thermometers, thermostats and dental amalgam. Target organs are the brain and kidneys.

Cadmium

Cadmium is a by product of mining and smelting of lead and zinc. It is used in nickel cadmium batteries, PVC plastic and paint pigments. It can be found soil because insecticide, fungicides, sludge and commercial fertilizer that used cadmium in agriculture. Cadmium may be found in reservoirs containing shellfish. A cigarette also contains cadmium. Laser non sources of exposure are dental allows electroplating, motor oil and exhaust. Inhalation account for 15-50% of absorption through the respiratory systems; 2-7% of ingested cadmium in absorbed in gastrointestinal system. Target organs are the liver, placenta, kidneys, lungs, brain and bones.

Copper

Copper is a naturally occurring element that is present in drinking water. Stagnation of water in pipes and plumbing fixtures containing copper and copper alloys in distribution systems and household plumbing allows leaching and increasing water copper levels [11]. Characteristics of the water, including increased acidity, increased temperature, and reduced hardness, can increase the leaching of copper into the water. Acute

ingestion of excess copper in drinking water is associated with adverse health effects, including acute gastrointestinal disturbances and chronic ingestion of copper can lead to liver toxicity in sensitive populations.

The following results have been drawn.

Arsenic: Out of the 50 samples, 30 samples didn't show any presence of Arsenic and out of 20 samples, which contain arsenic, it was found that quantity of Arsenic varied from 0.1 to 8.1 microgram/ liter.

Copper: Out of the 50 samples, 12 samples didn't show any presence of copper and out of 38 samples, which contain copper, it was found that quantity of copper varied from 0.7 to 177.3 microgram/ liter.

Mercury: Out of the 50 samples, 3 mercury amples didn't show any presence of m and out of 47 samples, which contain mercury, it was found that quantity of mercury varied from 0.4 to 140.1 microgram/ liter.

Lead: Out of the 50 samples, 50 samples didn't show any presence of lead and out of 32 samples, which contain lead, it was found that quantity of lead varied from 0.2 to 62.7 microgram/ liter.

Cadmium: Out of the 50 samples, 48 samples didn't show any presence of cadmium and out of 2 samples, which contain cadmium; it was found that quantity of cadmium varied from 0.4 to 34.4 microgram/liter.

Table 1: Surface water Arsenic in the surface water quantity of Arsenic varied from 0.4 to 2.1 microgam/liter. Copper in the surface water quantity of copper varied from 3.6 to 159.6 microgam/liter. Mercury in the surface water quantity of Hg varied from 1.9 to 109.5 microgam/liter. Lead in the surface water quantity of lead varied from 4.1 to 46.7 microgam/liter. Cadmium in the surface water quantity of Cd varied from 0.5 to 35.4 microgam/liter.

| S. No. | Location | Date | Time | As (mg/L) | Cu (mg/L) | Hg (mg/L) | Pb (mg/L) | Cd (mg/L) |
|--------|---------------------------|------------|----------|-----------|-----------|-----------|-----------|-----------|
| 1. | Laxmi Kund Shahar Jhansi | 11/02/2013 | 08:40 am | 1.0 | 159.6 | 109.5 | 46.7 | 0.0 |
| 2. | Laxmi Tal Jhansi | 13/02/2013 | 09:15 am | 0.0 | 0.0 | 75.2 | 26.2 | 0.0 |
| 3. | Pahuj River Lakara Jhansi | 14/02/2013 | 12:25 pm | 0.0 | 22.8 | 6.9 | 14.3 | 0.0 |
| 4. | Pahuj dam IGFR Jhansi | 14/02/2013 | 02:20 pm | 0.0 | 12.0 | 9.6 | 9.0 | 0.0 |
| 5. | Matatila Dam Lalitpur | 07/01/2013 | 11:50 am | 1.9 | 15.3 | 0.0 | 11.0 | 35.4 |
| 6. | Shahjad Dam Lalitpur | 07/02/2013 | 12:05 am | 0.0 | 79.0 | 0.6 | 5.5 | 0.5 |
| 7. | Talbehat ka Talab | 09/01/2013 | 01:40 pm | 0.4 | 9.8 | 5.8 | 12.2 | 0.0 |
| 8. | Rajghat Canal Lalitpur | 05/01/2013 | 10:25 am | 0.4 | 17.0 | 1.9 | 9.9 | 0.0 |

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|-----|-----------------------------|------------|----------|-----|------|------|------|-----|
| 9. | Meranka Talab Tajbehath | 11/01/2013 | 05:50 pm | 0.0 | 15.1 | 8.9 | 6.1 | 0.0 |
| 10. | Matatila Canal Babina | 10/02/2013 | 09:45 am | 0.0 | 19.9 | 9.5 | 4.1 | 0.0 |
| 11. | Betwa Canal Badaganv Jhansi | 11/02/2013 | 02:00 pm | 0.0 | 3.6 | 1.9 | 28.1 | 0.0 |
| 12. | Pareechha Dam | 13/02/2013 | 11:30 am | 1.4 | 0.0 | 17.1 | 12.4 | 0.0 |
| 13. | Betwa River Orchha | 25/01/2013 | 11:00 am | 0.0 | 41.9 | 14.7 | 6.2 | 0.0 |
| 14. | Yamuna River Kalpi Jajaun | 27/02/2013 | 01:00 pm | 1.5 | 0.0 | 48.0 | 4.4 | 0.0 |
| 15. | Talab Orai Jalaum | 28/02/2013 | 03:00 pm | 2.1 | 0.0 | 49.9 | 0.0 | 0.0 |

Table 2: Ground Water:
Arsenic in the ground water quantity of Arsenic varied from 0.5 to 2.8 microgam/liter.
Copper in the ground water quantity of copper varied from 0.8 to 24.6 microgam/liter.
Mercury in the ground water quantity of mercury varied from 0.5 to 145.4 microgam/liter.
Lead in the ground water quantity of Arsenic lead from 0.5 to 39.7 microgam/liter.
Cadmium in the ground water quantity of cadmium was absent.

| S. No. | Location | Date | Time | As (mg/L) | Cu (mg/L) | Hg (mg/L) | Pb (mg/L) | Cd (mg/L) |
|--------|----------------------------------|------------|----------|-----------|-----------|-----------|-----------|-----------|
| 16. | Hand pump Medical College Jhansi | 05/02/2013 | 09:10 am | 0.0 | 0.0 | 4.0 | 4.8 | 0.0 |
| 17. | Handpump Pareecha | 10/02/2013 | 01:10 pm | 0.0 | 24.6 | 145.4 | 11.9 | 0.0 |
| 18. | Handpump Badaganv Jhansi | 13/02/2013 | 05:30 pm | 0.0 | 0.0 | 64.7 | 7.5 | 0.0 |
| 19. | Handpump Friends Colony Jhansi | 22/02/2013 | 02:30 pm | 0.0 | 20.1 | 27.9 | 0.0 | 0.0 |
| 20. | Handpump Badapul Jhansi | 28/01/2013 | 04:40 pm | 2.8 | 0.0 | 18.6 | 0.0 | 0.0 |
| 21. | Handpump Railway Crossing Jhansi | 22/01/2013 | 01:00 pm | 0.0 | 4.0 | 0.0 | 0.0 | 0.0 |
| 22. | Handpump Ritubihar Jhansi | 24/01/2013 | 06:00 pm | 0.0 | 1.2 | 3.9 | 0.0 | 0.0 |
| 23. | Handpump Pathoria Jhansi | 22/01/2013 | 04:00 pm | 0.5 | 0.0 | 12.9 | 0.0 | 0.0 |
| 24. | Handpump Palcolony Jhansi | 20/02/2013 | 05:30 pm | 0.6 | 8.3 | 18.7 | 0.0 | 0.0 |

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|-----|---------------------------------|------------|----------|-----|------|------|------|-----|
| 25. | Well Swamipuram Jhansi | 14/02/2013 | 10:00 am | 0.0 | 0.0 | 10.5 | 0.5 | 0.0 |
| 26. | Handpump Swaraj Tractors Jhansi | 14/02/2013 | 12:30 am | 0.0 | 2.9 | 26.7 | 0.0 | 0.0 |
| 27. | Well Home-Guard Jhansi | 15/02/2013 | 12:40 pm | 0.0 | 6.6 | 5.3 | 12.9 | 0.0 |
| 28. | Well Pathoria Jhansi | 14/02/2013 | 01:00 pm | 2.8 | 0.0 | 38.7 | 0.0 | 0.0 |
| 29. | Well I.G.F.R.I. Jhansi | 14/02/2013 | 02:00 pm | 0.6 | 10.6 | 14.6 | 0.0 | 0.0 |
| 30. | Well NRCF Jhansi | 16/02/2013 | 03:50 pm | 0.0 | 2.5 | 0.5 | 2.3 | 0.0 |
| 31. | Well Lakara Jhansi | 17/02/2013 | 04:50 pm | 0.5 | 0.0 | 13.4 | 3.7 | 0.0 |
| 32. | Well Buda Ganv Jhansi | 14/02/2013 | 04:00 pm | 0.0 | 2.1 | 0.0 | 0.0 | 0.0 |
| 33. | Well Bhojla Jhansi | 18/02/2013 | 04:00 pm | 0.0 | 5.9 | 18.8 | 0.0 | 0.0 |
| 34. | Well D.A.V Pathoria Jhansi | 14/02/2013 | 10:30 pm | 0.0 | 0.8 | 28.5 | 39.7 | 0.0 |

Table 3: Factory Outlets
Arsenic in the ground water quantity of Arsenic varied from 2.9 to 8.1 microgam/liter.
Copper in the ground water quantity of copper varied from 19.3 to 84.7 microgam/liter.
Mercury in the ground water quantity of mercury varied from 7.7 to 160.8 microgam/ liter.
Lead in the ground water quantity of Arsenic lead from 19.6 to 27.5 microgam/liter.
Cadmium in the ground water quantity of cadmium was absent.

| S. No. | Location | Date | Time | As (mg/L) | Cu (mg/L) | Hg (mg/L) | Pb (mg/L) | Cd (mg/L) |
|--------|---------------------------------|------------|----------|-----------|-----------|-----------|-----------|-----------|
| 35. | Nala Pareechha Jhansi | 05/11/2013 | 02:50 pm | 8.1 | 84.7 | 0.9 | 0.0 | 0.0 |
| 36. | Wagan Repair Workshop Jhansi | 15/01/2013 | 02:10 pm | 3.6 | 32.0 | 9.8 | 27.5 | 0.0 |
| 37. | CWM Workshop Railway Jhansi | 19/02/2013 | 03:50 pm | 2.9 | 47.0 | 15.9 | 26.4 | 0.0 |
| 38. | JMK Motors Workshop Jhansi | 21/02/2013 | 01:00 pm | 0.0 | 42.3 | 160.8 | 19.6 | 0.0 |
| 39. | Plastic Sheet Factory Jhansi | 21/02/2013 | 04:30 pm | 0.0 | 19.3 | 7.7 | 16.7 | 0.0 |
| 40. | Hankul Packbell Plastic Factory | 22/02/2013 | 03:00 pm | 0.0 | 0.0 | 9.2 | 0.0 | 0.0 |

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