To Determine Arsenic Concentration (Using Atomic Absorption Spectroscopy) in Ground Water from Korba District (CG), India

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Abstract: Arsenic was discovered by Albertus Magnus in 1250 AD. Arsenic is the 20th most abundant element found on Earth. Arsenic behaves like both a metal and a non-metal because arsenic is a metalloid. The abundance of arsenic in the earth's crust is 1.5 to 2 ppm. Arsenic is the most toxic element found on Earth. Arsenic is found in natural water in the form of arsenite As^{3+} and arsenate As^{5+} ions. Whose solubility in water is high. Taking into consideration the harmful effects of arsenic on reaching human body through environment, it causes carcinogenic effects like skin cancer, lung cancer, bladder cancer, liver cancer, prostate cancer, leukemia, non-carcinogenic effects - neurological effects, memory and intellectual function, diabetes, cardiovascular disorder effects, effect on skin, effect on reproductive system, WHO and BIS have determined the concentration of arsenic in drinking water to be 0.1 mg/liter. In 50% of the samples of the study area, the arsenic concentration was more than the concentration determined by BIS and WHO, which varied from 0.18 ±0.007 to 0.88 ± 0.0051, which has proved harmful for the local residents. It can cause serious health risks to the local residents. It is very important to take water treatment measures to protect the local residents from the harmful effects of arsenic. There are many methods of water treatment like electrodialysis, coagulation, reverse osmosis, activated carbon filter, bioabsorbent etc. But water treatment by bioabsorbent is a suitable method at the rural level due to its low cost and easy availability anywhere.

Keywords: Arsenic solubility, carcinogenic effect, concentration of arsenic, water treatment method, bioabsorbent

Introduction

In the mind of the general public, the words “arsenic” and “poison” have become almost synonymous. Arsenic is used in a wide variety of industrial applications, from computers to fireworks. Mining and smelting activities are closely associated with Arsenic **(Jones, F. T., et al, 2007)**.About 70% of all arsenic used is in pesticides. The other uses of arsenic and arsenic compounds are in wood preservatives, glass manufacturing, alloys, electronics, catalysts, veterinary chemicals. The speciation of arsenic in environmental materials is of interest because of differing levels of toxicity exhibited by the various species. The major arsenic species found in environmental and clinical samples are as (lll), Arsenate, and Arsenious acids **(Garelick, H., et al, 2008).** Both As(lll) and As(v) are well absorbed from the gastrointestinal tract of the human. Between 45 and 75% of the dose of various As(lll) and As(v) forms are excreated in urine within the few days, which suggests that gastrointestinal absorption is both relatively rapid and extensive (**Henke, K.et al, 2009**). The element was first described by Theophrastus in 300 B.C. and named arsenikon (also arrhenicon; Caley and Richards 1956) referring to its “potent” nature, although it was originally considered an alternative form of sulfur (**Boyle and Jonasson et al 1973**). Arsenic, a metalloid occurs naturally, being the 20th most abundant element in the earth's crust, and is a component of more than 245 minerals. These are mostly ores containing sulfide, along with copper, nickel, lead, cobalt, or other metals. Arsenic and its compounds are mobile in the environment. Weathering of rocks converts arsenic sulfides to arsenic trioxide, which enters the arsenic cycle as dust or by dissolution in rain, rivers, or groundwater. So, groundwater contamination by arsenic is a serious threat to mankind all over the world (**Mandal, B. K., & Suzuki, K.T., 2002**). Arsenic is naturally occurring element present in the environment in both organic and inorganic forms. Inorganic arsenic is considered to be the most toxic form of element. A wide variety of adverse health effects, including skin cancer and cardiovascular and neurological effects, have been attributed to chronic arsenic exposure, primarily from drinking water (**Genchi, G., Lauria, G., et al, 2022**).Ingestion of arsenic, both from water supplies and medicinal preparations, is known to cause skin cancer(**Smith, A. H., Hopenhayn-Rich, C.,et al 1992**). Arsenic has more effects on health than any other toxicant, and the list continues to grow, along with evidence that exposure is widespread throughout the world (**Smith, A. H.,& Steinmaus, C. M. (2011**). Studies demonstrated that As (III) could be reduced from 200 µg/l to below 25 µg/l by the manganese greensand system. In the case of manganese greensand filtration, addition of iron in the ratio of 20:1 was found necessary to achieve this removal (**Villaescusa, I., & Bollinger, J. C. et al (2008**). In 2005, a conference was convened to bring together scientists involved in many of the different areas of As research.Arsenic (As) has been detected in groundwater in several countries of the world, with concentration levels exceeding the WHO drinking water guideline value of 10 µg/L (WHO, 2001) as well as the national regulatory standards (e.g. 50 µg/L in India and Bangladesh). In Asia, the impact of As toxicity is particularly alarming. For example, in the Bengal Basin of Bangladesh and West Bengal, India (**Bhattacharya et al., 1997**)Recent studies indicate the occurrence of geogenic As in the Central Gangetic Plains of Uttar Pradesh, Bihar, Jharkhand and the Brahmaputra valley in Assam, and several regions of Madhya Pradesh and Chattisgarh, India(**Chakraborti et al., 2004, Mukherjee et al., 2006**) . Following the discovery of Arsenics in the Chhattisgarh, there is now an urgent need to address the public health implications due to exposure from drinking water sources. In order to do this and initiate appropriate mitigation measures, there is an urgent need to identify the As-contaminated ground waters.The adverse effects of As in groundwater used for irrigation water on crops and aquatic ecosystems is also of major concern.

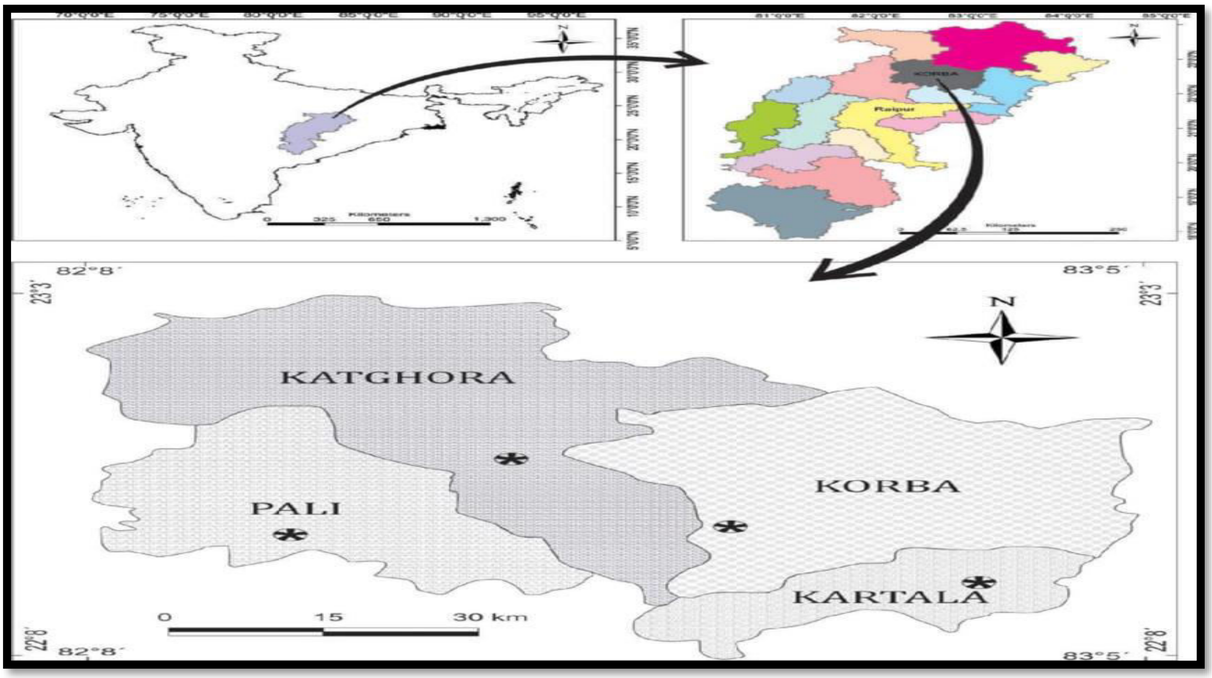
Field test kits offer a more practical tool than laboratory measurements within the time frame and financial resources available for screening and assessment of the As-contaminated wells as well as their monitoring. Simple, low-cost methods for As determination, such as the field test kits have proved to be most suitable for performing the TW screening quickly.(Bhattacharya, P., Welch, A. H., Stollenwerk, K. G., McLaughlin, M. J., Bundschuh, J., & Panaullah, G. (2007). Arsenic in the environment: biology and chemistry. Science of the total environment, 379(2-3), 109-120.)

Large quantities of As are released into the environment through industrial activities, which can be dispersed widely and as such play an important role in the contamination of soils, waters, and air (**Nriagu, 1989, Jacks and Bhattacharya, 1998, Juillot et al., 1999, Matschullat, 2000, Pacyna and Pacyna, 2001)**

Material and method

Study area

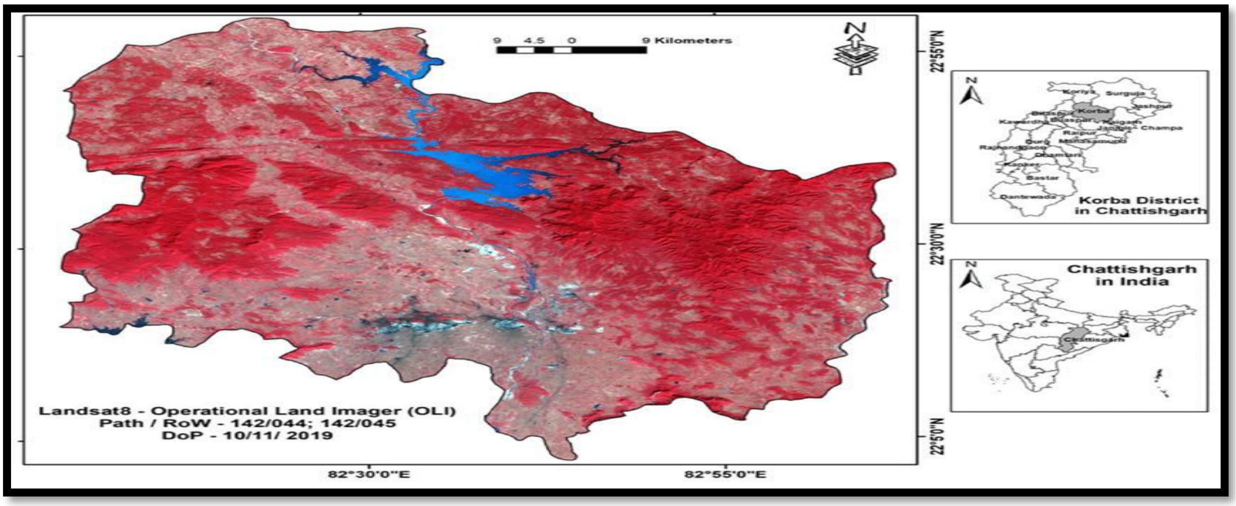
Contamination of groundwater can be due to both natural and anthropogenic reasons. Due to natural reasons, groundwater gets contaminated by volcanoes, eruptions, landslides, earthquakes, etc. The reason for the contamination of groundwater in the Korba district is the coal mine and thermal plant present there. Korba district is situated on the banks of the confluence of Hasdeo and Ahiran rivers. Korba district is called the powerhouse of Chhattisgarh state. Korba district is located 200 kilometers away from the capital Raipur. Korba district comes under the Bilaspur division. ,83,497 hectares of land. Korba district is surrounded by Koriya, Surguja, BilaspurJanjgir, and Raigad districts. The latitudinal extension of the Korba district is 22 01 to 23 01 and t longitude



Selection of sites

For spatial representation based on field survey, 18 rural areas were selected, viz. S1 Dodki Mohalla Mahua Pani, S2 Govt. Primary School Dodki, S3 Dodki Mohalla Bhelwatikara, S4 Navapara Mohalla Dugupara, S5 Navapara Mohalla Laripara, S6 Navapara Mohalla Dhawaiapara, S7 Chaitma Mohalla Basanpat1, S8 Chaitma Mohalla Basanpat2, S9 Girls Pre Madhyamik School Chaitma, S10 Kerakachhar Mohalla Bhilaipara, S11 Kerakachhar

Mohalla Sadakpara, S12 Govt. Primary School Kerakachhar, S13 Tivarta Mohalla Roadpara, S14 Govt. Pre Madhyamik School Tivarta Mohalla Roadpara, S15 Jhabar Mohalla Roadpara 1, S16 Jhabar Mohalla Roadpara 2, S17 Dipka Petrol Pump, S18 Pragati Nagar Dipka.



Sampling of groundwater:-

The sampling process is always an important part of environmental assessment. For an analytical study, test samples were collected in 1-liter plastic bottles from groundwater and surface water from 18 locations of the Gram Panchayat Dhodki and its surrounding villages in the month of December. The bottles selected for sampling were prepared beforehand by washing them with 1% nitric acid and distilled water. One percent nitric acid was added to the sample to make it 1% for the laboratory study.

Procedure:

1. **Prepare the Sample:**

- Measure 35.0 ml of your sample using a pipette.
- Put it into a clean generator bottle.
- Add these chemicals one by one, mixing well after each addition:
- 5 ml of concentrated hydrochloric acid.
- 2 ml of potassium iodide solution.
- 8 drops of stannous chloride solution.
- Let the mixture sit for 15 minutes. This waiting time allows the arsenic to fully change into a form called trivalent arsenic.

2. **Prepare the Scrubber and Absorber:**

For the Scrubber:

- Soak the glass wool inside the scrubber tube with lead acetate solution.
- Important: Do not make the glass wool too wet. Excess water could get carried over into the next solution and cause problems.

For the Absorber:

- Measure 4.00 ml of the silver diethyl dithiocarbamate reagent using a pipette.
- Put this measured reagent into the absorber tube(s).

3. Arsine Generation and Measurement:

a. Start the Reaction:

- Add 3 grams of arsenic-free zinc (20-30 mesh) to the prepared sample in the generator bottle.
- Immediately connect the scrubber tube (with lead acetate-soaked glass wool) to the generator.
- Immediately connect the absorber tube (containing 4.00 ml silver diethyl dithiocarbamate reagent) to the scrubber.
- Ensure all connections are air-tight.

b. Let Arsine Gas Form:

- Allow the reaction to proceed for 30 minutes. During this time, arsine gas will be produced (you should seebubbling).
- Gently warm the generator bottle (e.g., with your hands or in lukewarm water) towards the end of the 30 minutes. This helps release all the arsine gas.

c. Measure the Color:

- After 30 minutes, carefully disconnect the absorber tube.
- Pour the solution from the absorber tube directly into a 1-cm pathlength spectrophotometer cell (cuvette).
- Using your spectrophotometer, measure the absorbance (how much light the solution absorbs) at a wavelength of 535 nm.
- Use the reagent blank (prepared the same way but without any sample/arsenic) as the reference to set the instrument to zero absorbance.

Calibration Curve (Standard Curve):

- Prepare and run several standard arsenic solutions containing 0, 1.0, 2.5, 5.0, 7.5, and 10.0 micrograms (µg) of arsenic through the exact same procedure (Steps 1-3 above).
- Measure the absorbance of each standard solution.
- Make a graph (plot): On the X-axis put the concentration of arsenic in the standards (µg). On the Y-axis put the measured absorbance.
- Draw the best straight line (or curve) through these points. This is your calibration curve.

Calculation:-

- Use the calibration curve to find out how much arsenic (M, in micrograms (µg)) is present in the 4.00 ml of final solution measured in your sample's absorber tube.
- The concentration of arsenic in your original sample is calculated as follows:

Arsenic (mg/L) = M (µg) / V (ml)

Where:
M = Mass of arsenic found from the calibration curve (in micrograms, µg)
V = Volume of the original sample used (in milliliters, ml) = 35.0 ml (from Step 1)

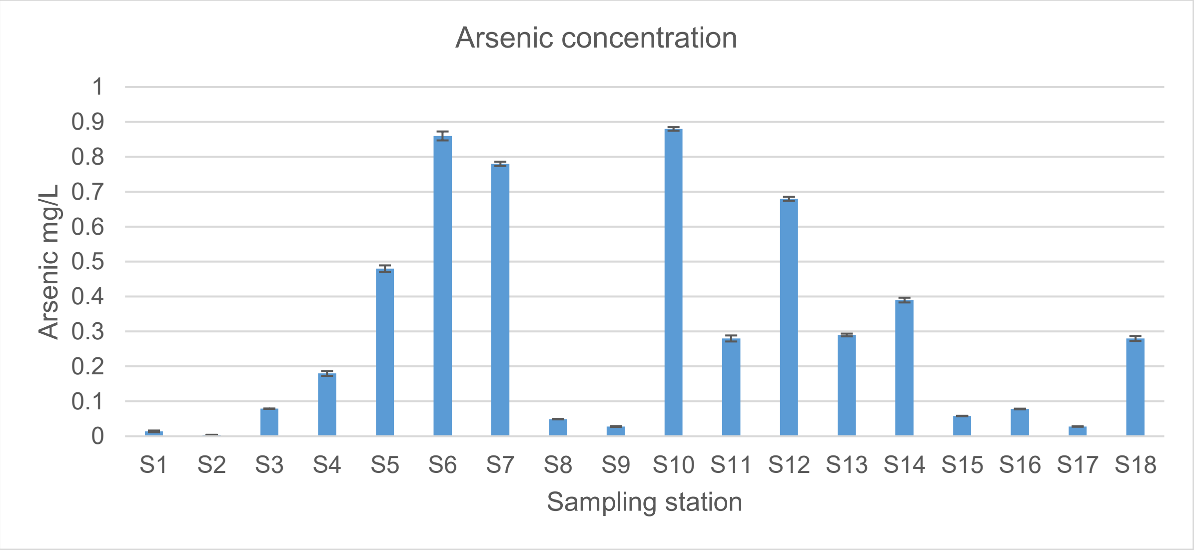
Result discussion:-

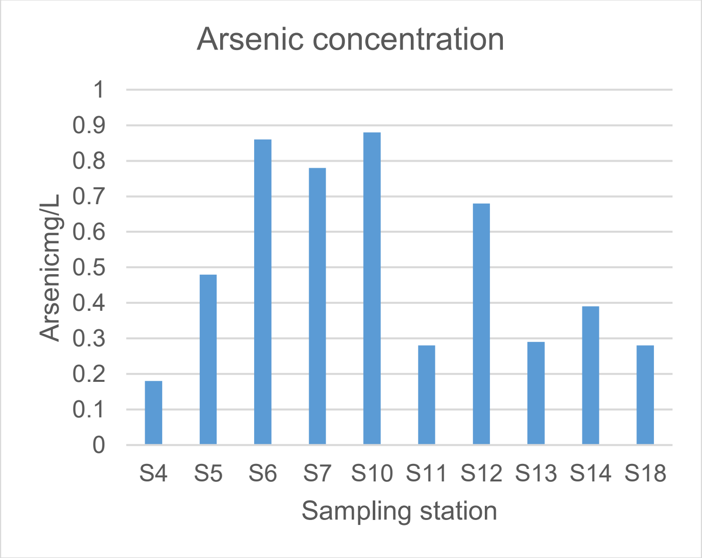
Arsenic is the 20th most abundant element found naturally in the earth in geological conditions, which contaminates groundwater and surface water through agricultural, industrial and mining wastes. Arsenic-containing water has been proven to be extremely harmful to human health. Keeping in mind the harmful effects of arsenic, WHO and BIS have determined the amount of arsenic in groundwater to be 0.1 mg/liter. Continuous long-term exposure to groundwater with concentrations higher than the prescribed arsenic concentration causes carcinogenic and non-carcinogenic health risks. Arsenic enters the human body through water and gets deposited in the skin, nails, hair, and tissues, causing health risks such as hyper pigmentation, keratosis, heart disease, skin, lung and internal cancer. Continuous long-term consumption of water with concentrations lower than the prescribed arsenic concentration can also lead to harmful effects such as increased risk of premature delivery, fetal damage, low birth weight of babies, etc. Arsenic concentration in 50% samples of the study area is more than the prescribed arsenic concentration by WHO and BIS. Arsenic concentration in the study area varies from 0.004 ± 0.0003 to 0.88 ± 0.0051 mg/liter. The highest arsenic concentration was in S10 with 0.88 ±0.0051 and the lowest arsenic concentration was in S2 with 0.004 ± 0.0003 mg/liter. Arsenic concentration in S4,S5, S6, S7, S10, S11,S12, S13,S14,S18 of the study area is more than the prescribed concentration. Natural sources are more responsible for arsenic concentration in groundwater of the study area than anthropogenic sources because metamorphic, sedimentary and igneous rocks are found here. Korba district is famous for coal storage and excavation. Electricity is produced from coal here. The waste material released during coal excavation and electricity production is the main source of arsenic concentration in groundwater. After this, there may be rock fracture, rock-water interaction, and agricultural waste.

SN	Sample location spot	Code of the groundwater sample	Arsenic report by Atomic absorption spectroscopy	Standard error	Sample source
1	Dodhki mahuaapani	S1	0.014	0.0024	Handpump

2	Govt primary school dodhki	S2	0.004	0.0003	Handpump
3	Dodhki bhelvatikara	S3	0.079	0.0002	Duckwell
4	Navapara dugupara	S4	0.18	0.007	Duckwell
5	Navapara laripara	S5	0.48	0.0092	Borewell
6	Navapara dhavaiyapara	S6	0.86	0.0128	Handpump
7	Chaitama basanpat 1	S7	0.78	0.0063	Handpump
8	Chaitma basanpat 2	S8	0.049	0.0007	Borewell
9	Govt. girls middle school chaitma	S9	0.028	0.0013	Handpump
10	Kerakchhar bhilaipara	S10	0.88	0.0051	Borewell
11	Kerakachhar bhilaipara	S11	0.28	0.0086	Handpump
12	Govt. primary school kerakachhar bhilaipara	S12	0.68	0.0058	Handpump
13	Tiwarta roadpara	S13	0.29	0.004	Duckwell
14	Govt.middle school tiwarta roadpara	S14	0.39	0.0068	Borewell

15	Jhaber roadpara road para 1	S15	0.058	0.0007	Borewell
16	Jhaber roadpara 2	S16	0.078	0.001	Borewell
17	Petrol pamp dipka gevara	S17	0.028	0.0008	Borewell
18	Pragti nagar dipka	S18	0.28	0.0071	Pond





Conclusion: Arsenic concentration in ground water was determined in the village panchayat Dhorki and its surrounding villages falling under Pali development block of Korba district of Chhattisgarh state. Arsenic concentration was determined with the help of AAS. In 50% of the test samples, arsenic concentration was more than the concentration prescribed by WHO and BIS, which varied from 0.004 ± 0.0003 to 0.88 ± 0.0051. Arsenic can be the cause of high blood pressure, skin infection, thyroid, intellectual disability, skin disease, kidney infection, arthritis in the study area. Arsenic enters the body through ground water, air and breathing. Arsenic affects many organs including heart, kidney, liver, lungs. Although arsenic can have many clinical symptoms, but the true diagnosis is awareness about the problem. There is a great need for water treatment to protect the residents of the study area from the ill effects of arsenic. Although there are many methods of water treatment, absorption by bioabsorbent is a suitable method for removing arsenic from groundwater at the rural level. Because removing arsenic from groundwater by bioabsorbent is a cheap, good and economical method, and bioabsorbent is easily available anywhere.

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