

Spectrophotometric Analysis of Underground Well Water Uranium of an Abandoned Coal Mines

P.K.Srivastava

Department of Applied Chemistry, Birla Institute of Technology, Deoghar Campus, Deoghar, Jharkhand

Abstract: Ground water analysis of privately owned wells water of a abandoned coal mines of highly carbonaceous coal was carried out. Ten water samples were collected from wells ranging from surface springs to 150 feet. The report of 10 well was documented after a interval of six months. Most of the water samples in these analysis were taken from the upper damodar valley and the river side. The majority of samples were collected from relatively shallow water wells, which supports the hypothesis that natural uranium mineralization generally occurs within 200 vertical feet. This may indicate that uranium mineralization has a much larger vertical range. It appears that concentration is well below the normal tolerance limit 30 µg/l.

I. Introduction

Coal mining at tackling the sticky surface clays, ground water, storm water control, materials handling ecology and environmental control involves both environmental and technological challenges. The maximum contaminant level (MCL) of 30 µg/l has been found in public water supplies [1- 4]. Uranium bearing coals generally occur less than 200 vertical feet below the unconformity which separates the sediments from the underlying sediments [5-8]. Most of the sedimentary rock directly below this unconformity belongs. The uranium in carbonaceous coal materials occur directly above or below a sandstone aquifer. The widely accepted explanation of mineralization is that percolating groundwater leached uranium from layers high in the stratigraphic section. The most likely source beds seem to be the sediments thought to have contained several volcanic ash deposits from which the uranium leached. As the uranium bearing groundwater moved vertically through the underlying strata, it would naturally follow the path of least resistance along permeable sandstone aquifers. This would continue until the uranium bearing groundwater came into contact with beds rich in organic carbon (highly carbonaceous shale's). The strong affinity of uranium for organic carbon concentrated the uranium in an amorphous organouranium complex in and near these high carbon beds.

II. Existence of Uranium into the Environment

Uranium is present naturally in virtually all soil, rock and water. Uranium in soil and rocks is distributed throughout the environment by wind, rain and geological processes. Rocks weather and break down to form soil. Soil can be washed by water and blown by wind. Uranium moves into streams and lakes and ultimately settling out and reforming as rock. Uranium may be removed and concentrated by people through mining and refining. The mining and refining processes produce wastes which may be introduced back into the environment by wind and water. Manufacturing of nuclear fuel and other human activities also release uranium to the environment. All uranium isotopes are radioactive. The three natural uranium isotopes found in the environment U-234, U-235 and U-238 undergo radioactive decay by emission of an alpha particle accompanied by weak gamma radiation. The dominant isotope U-238 forms a long series of decay products that includes the key radionuclides radium-226, and radon-222. The decay process continues until a stable, non-radioactive decay product is formed. The release of radiation during the decay process raises health concerns. A person can be exposed to uranium by inhaling dust in air and ingesting water and food. The general population is exposed to uranium primarily through food and water. The average daily intake of uranium from food ranges from 0.07 to 1.1 micrograms per day. The amount of uranium in air is usually very small. Uranium can enter the body when it is inhaled / swallowed and under rare circumstances it may enter through cuts in the skin. Uranium can not be absorbed through the skin and alpha particles released by uranium cannot penetrate the skin, so uranium that is outside the body is much less harmful. When uranium gets inside the body it can lead to cancer or kidney damage. About 99 percent of the uranium ingested in food or water will leave a person's body in the feces and the remainder will enter the blood. Most of this absorbed uranium will be removed by the kidneys and excreted in the urine within a few days. A small amount of the uranium in the bloodstream will deposit in a person's bones, where it will remain for years

III. Faith of Uranium on Health

Intakes of uranium exceeding limit standards can lead to increased cancer risk and liver damage. Long term chronic intakes of uranium isotopes in food, water and air can lead to internal irradiation and chemical toxicity[9-10]. Uranium in a urine and stool sample can be measured. These tests are useful if a person is exposed to a large amount of uranium because most uranium leaves the body in the feces within a few days after ingestion. Uranium can be found in the urine for several months after exposure. However the amount of uranium in the urine and feces does not always accurately show the level of uranium to which one have been exposed. Since uranium is known to cause kidney damage, special urine tests are often used to determine whether kidney damage has occurred. Some time household wares may be found with uranium in them e.g. some older ceramic dishes or plates in which uranium was used in the glaze. The maximum dose to an individual from uranium in the air is 10 milligram. Site-specific factors, cost, and community concerns are weighed in establishing the actual clean up value. Uranium in drinking water is covered under the safe drinking water act. This law establishes maximum contaminant levels (MCL) for radionuclide's and other contaminants in drinking water. The uranium limit is 30 µg/l in drinking water. Naturally occurring uranium has very low levels of radioactivity. However, the chemical properties of uranium in drinking water are of greater concern than its radioactivity. Most ingested uranium is eliminated from the body. However a small amount is absorbed and carried through the blood stream. Studies show that drinking water with elevated levels of uranium can affect the kidney over year's time.

IV. Population at Risk

Some water samples have been taken from southwest of the damodar river for analysis. The samples were collected from the shallowest and deepest groundwater. In this paper the survey revealed that the sampled had levels near or below detection levels for uranium and generally close to the proposed MCL for in water. It appears that most uranium mineralization occurs at depths of less than 150 feet. By applying a depth criterion of 150 feet and by eliminating surface water supplies and those systems which have been sampled and found safe. Rigorous analysis was attempted of wells in both studies shows that there has been any significant change over the 6 months separating these two studied. The uranium concentrations in identified wells were strikingly similar in both studies and well within the ranges which would be expected.

V. Methodology

Sampling

Sample was collected in clean and dry container. It was analysed within 48 hours of collection. Samples were collected after purging water for 15 minutes and water was collected directly from the well. Data regarding depth, construction, age, and use was collected from the well owner. Water samples were collected in 1-liter polypropylene containers for inorganic anion analysis. Samples preserved with 2 millilitres of concentrated nitric acid. All containers were double rinsed with the source water prior to collection immediately after collection all samples were stored in iced coolers for transport to the laboratory. Samples were tested within 4 days.

Analysis

A UV/Visible spectrometer of Simadzu model UV-1800 equipped with a recording device was employed for measurement of optical density. Absorption measurements at fixed wavelength were performed with 1- cm quartz cells. A pH meter with a combined glass electrode was used for pH measurements. All chemicals of analytically grade and double distilled water were used. Standard solution of uranium (1000 µg/ml) was prepared by dissolving 0.2110 g of uranyl nitrate hexahydrate in 3 ml concentrated sulfuric acid and diluting to volume with deionized water in a 100 ml volumetric flask. Arsenazo-III was prepared by dissolving 0.25 g Arsenazo-III in 0.5 N NaOH and diluting to volume with deionized water in a 100 ml volumetric flask. DTPA solution (2.5 %) was prepared by dissolving 25 g diethylenetriaminepenta - acetic acid (DTPA) in 1000 ml deionized water and dropwise addition of 0.5 N NaOH. Tartaric acid (10 %) was prepared by dissolving 10 g of tartaric acid in 100 ml deionized water. An aliquot of sample solution containing less than 200 µg of uranium was transferred into a 50 ml volumetric flask. 2 ml of DTPA, 1 ml of tartaric acid and 1 ml of arsenazo-III reagent solution were added. The solution was taken up to the mark with dilute H₂SO₄ (pH 2.0). After 5 min, the absorbance of the pink-violet complex at 651 nm in a 1cm cell was determined against a reagent blank as the reference.

VI. Results and Discussion

Uranium is a common element in bedrock in many parts of the world and is likely to contain a detectable level of uranium. The form of uranium most common to this area does not pose a risk of radiation due to a half-life in the billions of years. It is also a heavy metal like cadmium, lead and can accumulate in

kidneys. High concentrations over extended periods of time can adversely affect kidney function. Due to the highlands geology, the likely source of radioactivity in drinking water is uranium, radon, or both. Different tests for uranium determination are photometry, laserphotometry, liquid scintillation, gama spectrophotometry and alpha spectrophotometry. A gross alpha test is the first step in determining the type and level of radioactivity in drinking water [11-12]. This test serves as a preliminary screening and determines whether additional testing is advisable. The gross alpha standard (15 pCi/L) is calculated by first measuring gross alpha activity and then subtracting the uranium and radon contributions from this value. If the gross alpha test result is above 15 picocuries per 2 liter, then further testing for uranium, radium and radon is recommended. Since all of these radionuclides are found, with uranium and radon being the most prevalent, the additional tests are necessary in order to ensure the correct treatment is installed. Each requires a different kind of treatment system. The standard for uranium is 30 micrograms per liter ($\mu\text{g/L}$).

The photometry method is based on the arsenazo (III) complex formed with U(IV). The absorbance of the solution at 550–750 nm was measured against a reagent blank as the reference. The absorption spectra of the uranium (VI)–arsenazo-III complex are shown in Fig. 1. As shown, the maximum absorption of the pink-violet complex occurred at 654 nm. At this wavelength, arsenazo-III did not demonstrate any respected absorption. A pink-violet complex was obtained with λ_{max} at 651 nm due to the interaction of uranyl ion with arsenazo-III while arsenazo- III showed negligible absorbance at 651 nm. The reaction was carried out at 298 K and the absorbance of the colored complex was measured after 5 min at 654 nm. Therefore the absorbance measurement as a function of initial concentration of uranyl ion was the basis of spectrophotometric determination of uranium (VI). Fig. 2 reveals the relationship between concentration of uranium ions and absorbance at $\lambda_{max} = 654 \text{ nm}$, as determined formerly. The concentration range 1–25 $\mu\text{g/g}$ obeyed Beer's law and the detection limit was 0.025 $\mu\text{g/g}$. The data have been are summarised in table 1.

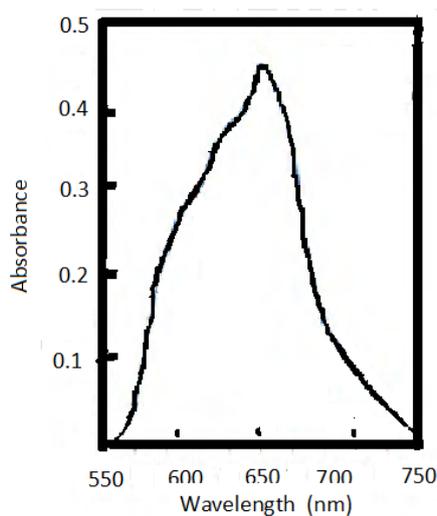


Fig. 1. Absorption spectra of Uranium (VI)-arsenazo-III complex

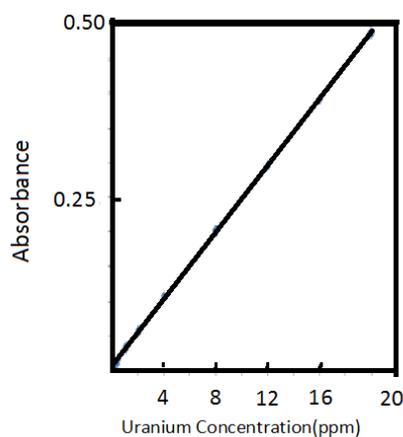


Fig. 2. Calibration curve for spectrophotometric determination of uranium. Color intensity was determined at 654 nm

Table 1 Variation of average depth against average concentration(October/ November)

Sl. No	sample taken per well	Average depth ft.	Average concentration $\mu\text{g/L}$
1.	03	10	2
2.	03	20	8
3.	03	30	10
4.	03	40	16
5.	03	50	15
6.	03	60	16
7.	03	70	15
8.	03	100	15
9.	03	120	20
10.	03	150	20

A study of short term variation in uranium concentration was done. The sample were taken between March/ April and October/ November. Sample numbers used here are averages of two or more samples from the same well. A total of 10 water samples were collected. Water supplies sampled in this survey ranged from shallow, surface springs to wells of 200feet. The majority of water supplies exhibiting uranium concentrations less than 20 ug/l were at depths less than the average. A brief summary of the data are given in the following table 1 &2.

Table 2 Variation of average depth against average concentration(March/April)

Sl. No	sample taken per well	Average depth ft.	Average concentration $\mu\text{g/L}$
1.	02	10	4
2.	02	20	10
3.	02	30	12
4.	02	40	16
5.	02	50	14
6.	02	60	16
7.	02	70	14
8.	02	100	15
9.	02	120	18
10.	02	150	20

Depth and geologic considerations regarding uranium seem to support the mineralization model. The most highly concentrated and widespread occurrences of uranium in ground water appear to be found fairly near the land surface. The majority of elevated uranium concentrations occur at depths of less than 150 feet. The survey of 10 water supplies sampled only 10 wells which had reported depths of greater than 50 feet. The relationship of well depth to uranium concentration is shown in table 1&2 for each survey. There is a maximum uranium concentrations at well depths of about 150 feet. For depths over 150 feet, uranium concentrations are generally quite low although most uranium occurs at depths of less than 100 feet. There is also data which supports the theory of a much broader vertical distribution of uranium in this area. The integral role of highly carbonaceous strata cannot be confirmed by these studies due to the nature of the sampling methods. Many of the wells predate the water well construction. It is assumed however that the accepted mineralization model applies across the area and at all depths. Review of exploration activity records may verify the presence of highly carbonaceous beds immediately above or below affect sandstone aquifers. Based on literature and a limited amount of sampling data it appeared that uranium mineralization was vertically limited. Deep monitoring wells at the abandoned coal mines had significantly lower concentrations of uranium than did the shallow wells. The geology also suggested that deposition of the uranium was limited to the upper portions. The survey was initially limited to wells with depths of less than 150 feet although this number was later reduced to 100 feet based on the number of wells encountered.

VII. Conclusion

During the monitoring it was discovered that water from some shallow aquifers outside the mine boundaries exhibited naturally occurring uranium concentrations as high as 20 micrograms per liter ($\mu\text{g/l}$). A total of 10 water samples were collected from 10 wells and homes in an area extending from the areas covered. The study area is characterized by bedrock sediments of Damoder valley proceeding stratigraphically. The most extensive geologic formations of the area is the major focus of this study. Samples were taken to determine the concentration of uranium in drinking water sources in damodar valley area. The second survey conducted after six months in uniform manner. Chemical and physical associations of uranium in ground water with depth of wells were determined. The *maximum contaminant level* for uranium in public water supplies is $30\mu\text{g/l}$. However, since results can vary widely from season to season, it is prudent to re-test whenever the results are above $10\mu\text{g/l}$.

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