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Boron Concentration Measurement in Well Water

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ABSTRACT

The present work used ICP-OES (Inductively Coupled Plasma/Optical Emission Spectrometry) and SSNTDs (Solid-State Nuclear Track Detectors) to evaluate boron quantities in 9 water well samples collected from various places in Basrah governorate's south. Boron concentrations in the ICP-OES method ranged from (4.3 - 9.3) mg/L, with an average value of 6.493 mg/L. In the SSNTDs, boron concentrations ranged from (4.8 - 9.8) mg/L, with an average value of 6.766 mg/L. Results obtained from water well samples using ICP/OES methods, SSNTDs respectively exceed the permissible limits of 5.0 mg/L in these regions.

1. Introduction

Boron is a naturally occurring and widely dispersed element in natural ways but is not present in its free form; where the Earth has more than 200 boron compounds, only 12 are economically relevant when they are widely disseminated in the environment. The first known borate mineral is sodium tetraborate decahydrate $Na_2B_4O_7 10H_2O$ or borax. Boron may build extremely fast in soils irrigated with boron-containing wastewater but at low concentrations in soil and irrigation fluids. The concern of specific organizations, such as the National Academy of Sciences and the National Academy of Engineering, is to investigate the impact of boron as a key irrigating factor (Rathore & Khangarot, 2003). Boron may be found in oceans, sedimentary rocks, especially clay-rich marine sediments, coal, shale, and soil (Algrifi & Salman, 2022a). Boron is an essential component of the human diet since it involves cell membrane function and enzymatic processes.

It is a necessary element for plants, and a lack of it affects plant growth, yield, and agricultural production. However, large quantities of boron are harmful to plants and diminish output. Because boron is essential for life, small amounts of boron compounds reinforce the cell walls of all plants, making it a critical plant nutrient (Salman & Fleifil, 2015). Boron is released into groundwater as a result of leaching from boron-containing rocks and anthropogenic sources such as oil and coal power plants, wood burning, glass product manufacturing, boron compounds (borates/perborate) as a bleaching agent in detergents, borate mining/processing, wood leaching Processed paper, consumer products (such as cosmetics, pharmaceuticals, inoculations, etc.) (Algrifi & Salman, 2022b). The $^{10}B(n,\alpha)^7Li$ neutron capture reaction makes it useful in various research fields, including nuclear physics, astronomy, and medicine. Boron is important in the nuclear power industry because of its strong neutron absorption cross-section. Boron, in the form of boric acid, is used in the primary cooling system of pressurized water reactors (PWRs) to control the reaction of the core.

It is also utilized as a source of short-range alpha particles in a cancer treatment called boron neutron capture therapy (BNCT), which is a new approach to killing malignant cells using labelled ^{10}B chemicals and neutron radiation. Compared to other biologically common atoms such as carbon, hydrogen, nitrogen, oxygen, or the possibility of capturing a ^{10}B atom, B compounds have a

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large cross-section of neutrons (3840 barns) (You, et al., 1995).

This study has used ICP-OES technology and a SSNTDs (CR-39) to evaluate the uranium concentration in selected water well samples obtained from different areas in south Basrah, Iraq. This study was conducted in these regions due to a lack of previous research and the establishment of a database of boron contents in water well samples.

2. Materials and Methods

Water Sample Collection

In this investigation, one water well sample was taken from each of the nine different locations in the Basrah governorate of southern Iraq. Samples of the well's water were collected at a 15 cm depth inside the well. Table 1 shows the many areas of study. These water samples were kept in 250 ml transparent plastic containers that were half-full of water and completely airtight.

Analytical Determination of Boron

Boron in drinking water may present a health problem if it exceeds a specified concentration threshold. Therefore, it is crucial to know how much boron is in the soil and water. For Boron determination, various analytical methods have been employed, ranging from a simple Spectrophotometric approach to a technique requiring a nuclear reactor such as:

Inductively coupled Plasma / Optical Emission Spectrometry (ICP-OES)

The samples were heated to roughly 10000K in the ICP-OES method. This results in the atoms in the samples being excited and/or ionized. By emission, this ionized and excited atom is decaying to a lower energy state. A monochromator or polychromator disperses the distinctive emission lines of the atoms and ions, and the intensity of the lines is recorded using an appropriate detector. A spectrometer separates and measures the intensity of light emitted at a particular wavelength, By comparing the intensity value to calibration standards, an intensity value that can be converted to an elemental concentration is produced (Charles & Fredeen, 1997) employing an inductively coupled plasma, an optical emission spectrometer composed of:

1. Radiofrequency (RF) generator.

2. Argon gas supply (minimum purity 99.99%).

3. Computer-controlled emission spectrometer with background correction (Rüdel, et al., 2007).

Neutron Activation Analysis

An NAA analysis was carried out by immersing the sample in a beam of thermal neutrons and detecting the reaction product. When boron in a sample is exposed to an incident beam of thermal neutrons, the ^{10}B isotope undergoes the neutron-capture process described below:

$$^{10}B + {}_0{}^1n \Rightarrow {}^7Li(0.84\ MeV) + {}^4_2He\ \ (1.478MeV) + \gamma\ (0.48Mev)$$

All neutron activation analysis-based Boron determination methods measure the reaction's action products. The approach based on particle measurement is known as neutron capture radiography, whereas the method based on gamma(γ)ray measurement is known as prompt-activation analysis. These methods can detect boron in undamaged materials but require access to a nuclear reactor to generate thermal neutrons. Boron analysis has also been done using nuclear techniques employing non-neutron high-energy beams (Algrifi & Salman, 2022c).

For water samples, the practical technique is to place a precise volume of water (a few drops) on the CR-39 track detector materials that have previously been cut into similar sizes. The detectors are allowed to dry out at ambient temperature. The samples are then irradiated in the Nuclear Physics Laboratory at Ibn Al-Haytham Faculty of Pure Sciences / University Baghdad's Department of Physics, and placed in paraffin wax as a moderator at a distance of five cm from the neutron source (^{241}Am-^{9}Be) with a flux of 2.3×10^5 n/cm^2.s for 7 days and arranged in a circle around the neutron source as shown in Fig (1). Following irradiation, the detectors are etched in a (6.25N) NaOH solution at a temperature of 70 ^{0}C for (6 h). After the etching procedure, the detectors are removed, rinsed with distilled water, and dried. After then, the optical microscope was utilized to determine the number of alpha tracks (Algrifi & Salman, 2022b).

All samples, including the standard samples, were subjected to this technique. The boron content may be determined by comparing the sample's alpha-particle track density (tracks/mm^2) with that of a standard.

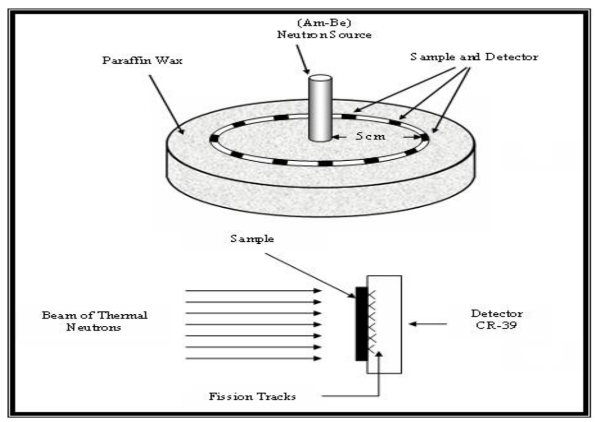

Fig. 1. A neutron source that emits thermal neutrons is used to bombard water samples and detectors (Algrifi & Salman, 2022c)

3. Results and Discussion

Table 1 shows the results of 9 water wells samples collected from South Basrah using ICP/OES. The concentration of boron in these studied samples ranged from 4.3 mg/L to 9.3 mg/L with an average value of 6.493 mg/L. The highest concentration of boron, 9.3 mg/L, was observed in the water sample collected from Al Shuaiba farm 2, whereas the lowest is 4.3 mg/L in the water sample from Um Qasr farm 1.

Table 1
Boron Concentration in South Basrah Water Wells Using ICP/OES

Numbers of Sites	locations	The concentration of Boron mg/L
W1	Um Qasr farm (1)	4.3
W2	Um Qasr farm (2)	6.82
W3	Um Qasr farm (3)	5.26
W4	Al-Shuaiba farm(1)	5.68
W5	Al-Shuaiba farm (2)	9.3
W6	Al-Shuaiba farm (3)	7.72
W7	Al-Shuaiba farm (4)	7.79
W8	Al-Shuaiba farm (5)	6.66
W9	Khor Al-Zubair Farm(1)	4.91
Average		6.493
Max		9.3
Min		4.3

Table 2 shows the results of 9 water wells samples collected from South Basrah measured using the SSNTDs method. The concentration of boron in these studied samples ranged from 4.8 mg/L to 9.8 mg/L with an average value of 6.766 mg/L. The highest concentration of boron, 9.8 mg/L, was observed in the water sample collected from Al-Shuaiba Farm 2, while the lowest was 4.8 mg/L in the water sample from Umm Qasr Farm 3.

Table 2
The boron Concentration in South Basrah wells by SSNTDs

Numbers of Sites	Locations	Tracks density (ρ) (tracks/mm2)	The concentration of Boron (mg/L)
W1	Um Qasr farm (1)	5342	7.3
W2	Um Qasr farm (2)	4708	5.5
W3	Um Qasr farm (2)	4461	4.8
W4	Al-Shuaiba farm (1)	4789	5.73
W5	Al-Shuaiba farm (2)	6224	9.8
W6	Al-Shuaiba farm (3)	5536	7.85
W7	Al-Shuaiba farm (4)	5589	8
W8	Al-Shuaiba farm (5)	5138	6.72
W9	Khor Al-Zubair Farm(1)	4602	5.2
Average		6.766	
max		9.8	
min		4.8	

4. Conclusions

ICP-OES and SSNTDs were used to measure boron concentration in water well samples. According to the results of this study, the concentration of boron in these sites is higher than in residential sites; because these sites contain repair factories, and the disposal of industrial waste, which raises the concentration of this element in these areas. Nevertheless, the readings were more than 5.0 mg/L, which is way over the limits allowed in these places. Due to the surroundings of the well, including precipitation, low and high temperatures, and its closeness from the sewage network, as well as leaching from rocks and soils containing borates and borosilicates, there is a greater concentration of boron in the well water.

Competing Interests

The authors had no competing interests.

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