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Boron Determination in Basrah Rivers Using Solid State Nuclear Track Detector

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A B S T R A C T

Consumers who ingest boron-contaminated food and water face a variety of health concerns. As a result, the food boron content must be determined. For this research, drinking water samples were collected from different areas in southern Basrah, Iraq. The collected water samples were examined using the SSNTDs method to determine boron levels. Boron values in the Al Khatwa district ranged from 0.21 ppm to 9.8 ppm in Al Shuaiba farm2. The results of this investigation were compared to worldwide standards and prior studies. The Iraqi government may use these data to establish guidelines for reducing radioactive pollution of Basrah's drinking water. The boron levels in the 43 surface water samples evaluated in this study were lower than the international standard limits. However, there are some regions where the rates are quite high. As a result, in most areas, the boron level in Basrah's drinking water is normal. However, there is a possibility that boron pollution will become a major issue soon. As a result, further research will be needed in the future.

1. Introduction

Boron is an element that may be found in rocks, soil, and water. It is a member of the non-metallic family of elements. It has an atomic number of 5 and a weight of 10.81. Boron has two isotopes: boron-10, which has a 19.8% abundance, and boron-11, which has an 80.2% abundance (Nielsen, et al., 1992). Boron levels in the Earth's crust are thought to be fewer than 10 parts per million, although they are as high as 100 parts per million in places where they're higher (Young, 2008). Solid state nuclear track detector (SSNTDs) of diverse materials are beneficial for scientific and technological study at the fundamental level (Parks & Edwards, 2005). SSNTDs are frequently used in the fields of radiation protection and environmental radiation monitoring. SSNTDs were found a few years ago; Salman et al (2015) explained the fundamental principles, while (Parks, 2005) offered a thorough explanation. The specifics of alpha particle detection were reported by Nikezic (Tu, et al., 2010).

As a consequence, some aspects of interest in this study are merely highlighted. Two basic requirements must be met, depending on the chemical treatment (called etching) and observation technique: the particle range and energy deposition must be acceptable (Hermsdorf, 2009). This research describes the preliminary findings of boron level detection data collected from a variety of locations in Southern Basrah, Iraq. The main goal is to look at the complicated changes and interactions that occur with water flow, as well as to figure out how dangerous these fluids are. The research center is actually located in the Southern Basrah. The chemical structure of boron is shown in Figure 1.

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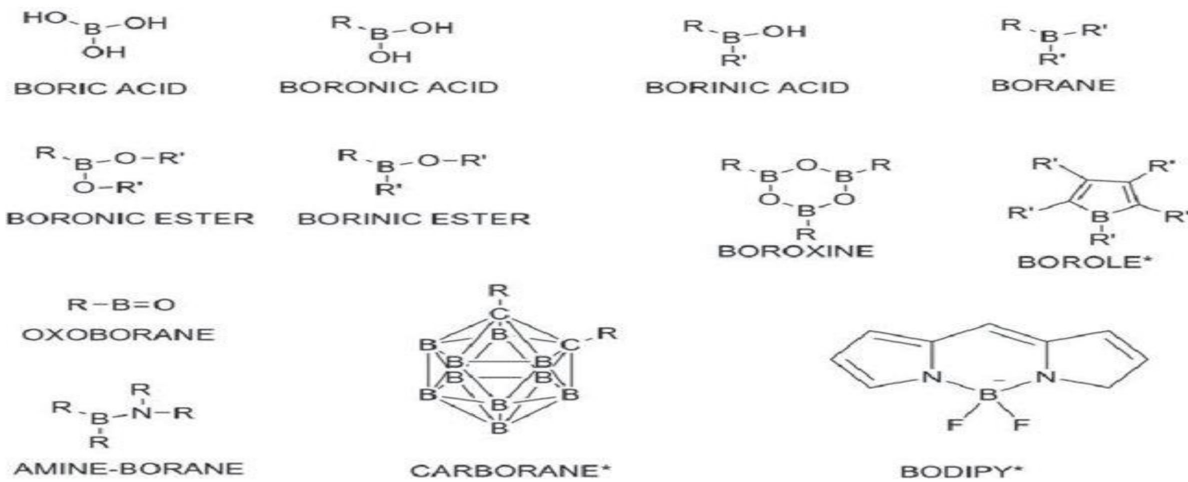

Fig. 1. Boron-containing compounds (BCCs). The fundamental core structures for BCCs

SSNTDs of various materials are critical for basic research and technological advancement (Salman & Qasim, 2013). SSNTDs are commonly used in radiation monitoring and protection in the environment. Some years ago, a study conducted by Somogyi & Szalay, (1973) and Durrani, & Bull, (2013) proposed the core principles of SSNTD theory. From the perspective of the BNCT (Nikezic & Yu, 2003), the details of alpha particle detection are critical. A sample containing one of the recognized boron compounds, even if only in trace amounts, is required for the 10BNCreaction to occur, and hundreds are involved in today's applications and on a rising level, 10B, a source fixed for radioactivity with thermal or minor neutron energy, is required for the 10BNCreaction to occur (0.025eV or lower), and a reaction fragment identifying method is required. When a neutron collides with a boron nucleus, it disintegrates into two shards of the 10B+n compound nucleus (to set aside a little amount of time, on the range of picoseconds). The two pieces are the first to get kinetic energy as a result of the strong Coulomb field going in the opposite direction, which is generated via the following procedure:

$$^{10}B+n\rightarrow[^{11}B]\begin{cases}\rightarrow {}^{7}Li+{}^{4}He+2.79MeV & \text{(branching ratio 6.1\%)}\\ \rightarrow {}^{7}Li+{}^{4}He+\gamma(0.48MeV) & \text{(branching ratio 93.9\%)}\end{cases} \quad (1)$$

The first reaction has a lower frequency of occurrence (6.1 percent), but it is a better reaction with fewer photons, resulting in a higher Linear Energy Transfer (LET) or dE/dx. A 0.48MeV photon follows the opposite reaction, which happens sooner. Nuclear track techniques, for example, can be used to identify the alpha particle (4He+) if it has enough kinetic energy to travel over the sample surface. The alpha particle fingerprint, assuming a significant identifying significance, gives data on the presence of boron and is sufficiently predicted as an effective systematic approach for boron research. The key conclusions from boron amount data collected from different sites in Southern Basrah city are summarized in this study. Our major goal is to conduct a study on the complex exchanges and interactions that occur with water flow, as well as to identify the number of hazards that these fluids pose. As indicated in Figure 2, the research area is in southern Basrah/Iraq.

Fig. 2. Governorate of Southern Basrah Basrah's map courtesy of Google Earth

2. Material & Methods

Samples were collected from 43 stations and locations in the Basrah governorate in April 2021. Boron concentrations in water were determined using passive methods, namely SSNTDs. CR-39 films from the SSNTD (1x1 cm). A large number of water samples from diverse places have been supplied. One milliliter of various boron concentration standards is sprayed and allowed to dry onto the CR-39 track detector's identical region. The standard samples are subjected to a thermal neutron source for the same amount of time after drying (7 days). It has been discovered that a nuclear reaction of type 10B (n,α)7Li3 has happened. The CR-39 plastic detector can detect alpha particles with an energy of 2.31 MeV. After that, the samples are rinsed in distilled water before being immersed in a 6.25 N (Normality) NaOH solution at 600C for 6 hours in a bath kept at a constant temperature (etching duration). Track diameters and density were measured using a transmission optical microscope, and Boron concentration was determined using a suitable calibration curve. The components of each detector set were irradiated with neutrons generated by 241Am-9Be.

2.1. Irradiation of the Samples

As shown in Figure 3, the pellets (water samples) are shielded with a CR-39 detector and placed in a paraffin wax plate 5cm from the neutron source 241Am-9Be, with a thermal neutron flux of 5x103 n cm-2 S-1.

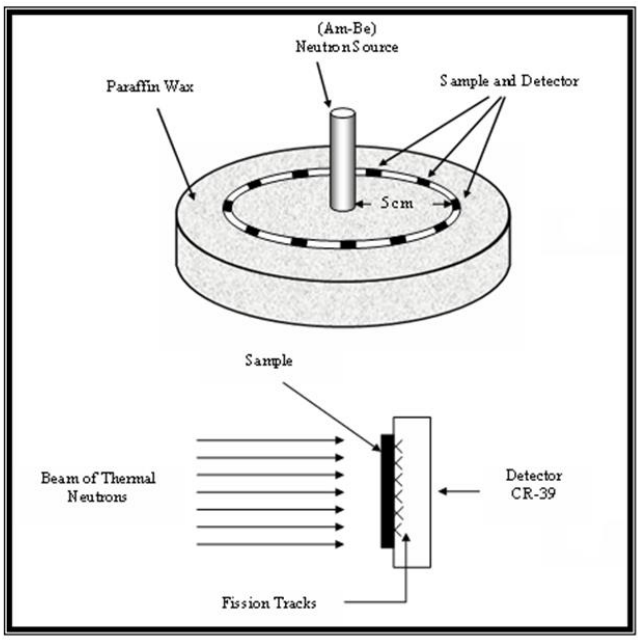

Fig. 3. Water samples and detectors being bombarded with thermal neutrons in front of a neutron source

2.2. Scanning using a microscope and chemical etching

After 7 days of radioactivity, the CR-39 detectors are removed and etched for 6 hours at 70 degrees Celsius in a 6.25 N aqueous solution of NaOH (Singh, et al., 2001). Before being air-dried, the detectors are washed with distilled water. An optical microscope with a magnification of 400 X is used to count the tracks verified in CR-39 detectors. The following formula is used to compute the density of the tracks in the detectors:

$$\text{Track density } (\rho_x) = \frac{Nave}{A} \quad (2)$$

Where ρ_x = Track density (Track/mm^2)

N=Average of total tracks , A= Area of field view (0.07 mm^2)

2.3. Water sample calibration curve

The curve plot between the standards for various boron solutions of specified concentrations has been set from 2ppm to 1ppm for the calibration of our study and the density of the track. Neutron-induced radiography (NIR) is a technique that involves the use of neutrons to produce images, a technique based on the CR-39 concept of solid-state nuclear detectors (SSNTDs). The boron content is determined by comparing the Regression equation to compare the track densities recorded on the detectors of the samples to those of the reference samples: y=2767.67+352.715*X, R^2 =0.97354. After observing a linear calibration, as shown in Figure 4, the slope factor was determined Within (mg B/l).

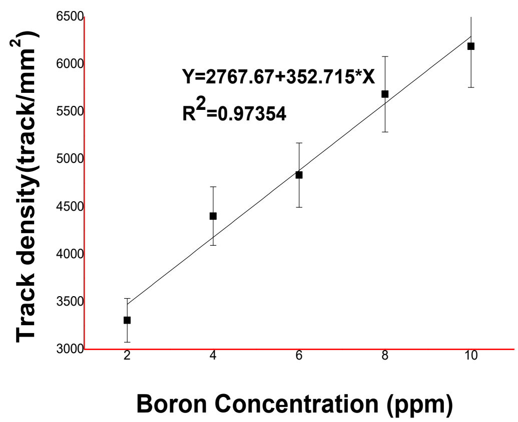

Fig. 4. Relationship between track density and Boron content (ppm), in typical Boron samples

3. Results & Discussion

A CR-39 detector was used to evaluate the track's density and Boron concentration samples, as indicated in Table 1. Water samples were taken from 43 locations around the Southern Basrah governorate. The relationship between Boron concentration and the number of water sample sites is depicted in Figure 5.

Table 1
In Southern Basra Governorate, the SSNTDS method used to determine the concentration of boron in the water

Sites numbers	Sites	Boron Concentration mg/L
W1	Sea side Dora	0.6
W2	Sihan	0.48
W3	Al Siba	0.52
W4	Ras Al Bisha	5.4
W5	FAO Center	1.5
W6	Al Mumlahih	5.8
W7	Hamdan	0.62
W8	Abu Mughira	0.57
W9	Al-Saraji	0.64
W10	mhjran	0.6

W11	muhilah	0.62
W12	Jaykur	0.6
W13	Al Baradhaiya	0.58
W14	Um Qasr farm 1	0.42
W15	Um Qasr farm 2	0.4
W16	Um Qasr farm3	4.8
W17	Um Qasr farm4	7.3
W18	Um Qasr farm5	5.5
W19	Um Qasr farm6	0.47
W20	Um Qasr Center	0.7
W21	Al Hadaama	7
W22	Khor Al Zubair Center	0.36
W23	Khor Al Zubair Farm1	5.2
W24	Khor Al Zubair Farm2	0.41
W25	Khor Al Zubair Farm3	0.4
W26	Zubair Center	0.28
W27	Al Easkari district	0.3
W28	Al Shuhada district	0.28
W29	Al Khatwa district	0.21
W30	Al Sahafiiyn district	0.5
W31	Al'athar	0.27
W32	Al Marbad	0.3
W33	Al Qaim District	0.24
W34	Al Burjsia	1.5
W35	Al Shuaiba Center	0.26
W36	Al Shuaiba farm1	5.73
W37	Al Shuaiba farm2	9.8
W38	Al Shuaiba farm3	7.85
W39	Al Shuaiba farm4	8
W40	Al Shuaiba farm5	6.72
W41	Al Siba (tap water)	0.44
W42	Hamdan (tap water)	0.5
W43	Jaykur (tap water)	0.51

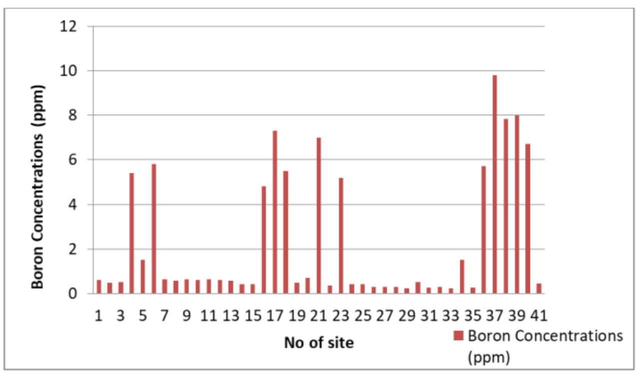

Fig. 5. Boron concentrations in Southern Basrah Governorate

Table 1 and Figure 5 were utilized to determine the level of boron in water samples. The data for these 43 samples, which are split into 40 sites extending from W1 to W43, are shown in Figure 5. Boron concentrations were observed to range from 9.8 ppm in Al Shuaiba farm2 to 0.21 ppm in Al Khatwa district. For health concerns, the World Health Organization (WHO) established a boron recommendation of 0.3 mg/L in 1993. This level was significantly increased to 0.5 mg/L in 1998. Furthermore, it was evident in 2000 that the 0.5 mg/L guidelines should be abandoned until data from ongoing research development may lead to modifications in the present viewpoint of boron toxicity or boron treatment technology (World Health Organization, 1998; Sivakumar, et al., 2012). In 1998, the European Union set a boron limit of 1.0 mg/L for drinking water (Directive, 1998; Shrivastava, et al., 2012). New Zealand has set a boron guideline for drinking water of 1.4 mg/L (Salman & Sweaf, 2019; Subber & Ali (2012). The safe boron concentration in Canada, according to (IMAC), is 5 mg/L. The Canadians came up with this figure based on current treatment technologies. It is presently impossible to decrease boron concentrations to fewer than 5 mg/L due to a lack of technology. When additional information becomes available, they will revisit this IMAC (Tallon, et al., 2005).

4. Conclusion

Soils may be found in a variety of rural settings, including Iraq's southern Basrah Governorate. Boron was found in chemical soil studies in New Zealand, with a limit of 1.4 ppm and an IMAC of 5 ppm, with a range of (0.21- 9.8) ppm.The boron content in the majority of water samples is low and below natural limits. But, some areas have high concentrations. There is a 97.35 percent correlation between the boron content of widely distributed samples and track density (track/m2) in water samples, which is an excellent connection. Having proper access to safe drinking water is essential for human health and is a major source of public health issues.

Competing Interests

The authors have declared that no competing interests exist.

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