Measurement Contamination of Boron in River Water in Dhi Qar-Iraq, using a nuclear detector (CR-39)

September 2024
DOI: 10.15980/j.tzzz.2024.07.09
https://virtus-interpress.org

Ihsan Al-Zaidi *, Abbas Abdelsuef

Received: 15th August 2024 Accepted: 16th September 2024 Published: 20th September 2024

Abstract

In this study, a comprehensive analysis of boron concentration in river water in Thi Qar Governorate, southern Iraq, was conducted, where water resources are essential for human survival, agricultural activities, and overall ecological balance. Boron, a semi-metal with distinct chemical and physical properties, is essential in small concentrations for plant growth, while increasing the concentration above a certain limit leads to toxic effects. Given the geographical and climatic characteristics of Thi Qar Governorate, understanding the spatial distribution and factors affecting boron levels is of great importance. Advanced analytical methods were used to measure boron concentrations, explore environmental and human factors affecting its fluctuations, and evaluate its impacts on public health and agricultural practices. Boron levels were measured at 16 river water stations, and a nuclear detector (CR-39) was used to measure boron concentration. Al-Dawaya station recorded the highest values of boron concentrations, ranging between (2.10 - 2.60) mg/L, with an average value of (2.33) mg/L. As for Karmat Bani Saeed station, it recorded the lowest concentrations of boron, ranging between (1.40 - 1.95) mg/L. The research aimed to enrich the effective management of water resources in Dhi Qar and provide a plan for conducting similar environmental assessments in other regions.

Keywords:
Boron concentration, Dhi Qar, river water, environmental health, agricultural sustainability, trace elements, water quality.

Introduction

Boron (B), a semi-metal residing on the border between metals and non-metals in the periodic table, boasts a unique chemical and physical properties. It is never found free but rather in various compounds such as borax and boric acid. Chemically, it is distinguished by its trivalent compounds, and physically, it is noted for its hardness and high melting point, making it invaluable in a range of industrial applications from creating fiberglass to ceramics [1-2]. The chemical structure of some boron compounds is found in (Figure.1) [3].

The environmental behavior of boron, especially in water systems, is of particular interest due to its dual role as an essential micronutrient for plants and a potential toxicant at higher concentrations. This duality has been observed most conclusively in agricultural areas such as Dhi Qar Governorate in southern Iraq, which is famous for its agricultural systems, which can lead to the use of pesticides and fertilizers containing boron, which can lead to water pollution that directly affects agricultural productivity and ecosystem health [4-6]. Therefore, this study is important to answer the question of whether boron may affect and cause water pollution.

(1) University of Al-Qadisiyah, College of education, Department of physics, phy.edu.post38@qu.edu.iq
(2) University of Al-Qadisiyah, College of education, Department of physics, Abbas.abd@qu.edu.iq

There is also a lack of monitoring and data on boron contamination in the waters of the Dhi Qar River, Iraq, making it necessary to conduct this study to assess the current situation and identify potential sources of contamination. Boron contamination can have adverse effects on human health, including kidney damage and reproductive problems. It can also harm aquatic life and affect the ecosystem, here lies the problem of this research.. The nuclear detector (CR-39) can provide a sensitive and accurate method for measuring boron contamination in river water, which is essential for effective monitoring. On the other hand, boron pollution of water can affect economic activities, such as agriculture and fishing, leading to material losses as river water is used in industry, so it is necessary to monitor its boron pollution to avoid negative effects on production. This study is very important, as it contributes to understanding the level of boron pollution of river water in Dhi Qar Governorate, which can help in taking preventive measures to protect human health and the environment, by providing valuable information about potential risks and assessing environmental and economic damage.

This research focused on exploring the preliminary results derived from the investigation of boron concentration levels, using data collected from different locations within Thi Qar city, Iraq. The primary objective of this investigation was to identify and compare the different interactions of boron with river flow in order to explore the potential hazards that these waters may pose.

The methodological study of this research relied on collecting and examining water samples from Thi Qar Governorate, due to the environmental importance of this region, which constitutes a unique confluence of environmental and hydrological factors, thus providing a compelling context for examining boron behavior and its environmental implications.

Solid State Nuclear Trace Detectors (SSNTDs)

The efficacy of Solid State Nuclear Track Detectors (SSNTDs) is contingent upon two critical factors: the particle's range and its energy deposition, which are significantly influenced by the chemical etching process and the observation method [7, 8].

Solid State Nuclear Track Detectors (SSNTDs) of varied compositions are pivotal in fundamental research across basic science and technology. These detectors are prevalently utilized in applications concerning radiation safety and environmental radiation monitoring. The conceptual underpinnings of SSNTDs were established several decades ago, with the foundational principles delineated comprehensively by Somogyi [9, 10]. Notably, the specifics of alpha particle detection assume critical importance in the context of Boron Neutron Capture Therapy (BNCT) [11, 12].

This investigation presents the initial findings from the collected data on boron concentration levels from various locations in Dhi Qar city. The primary aim is to delve into the intricate dynamics and interactions with the river flow and assess the potential hazards these waters pose.

2. MATERIALS AND METHODS

2.1. Collect water samples

Sixteen water samples were collected from different locations along the river in the Karmat Bani Saeed and Ad-Dawaya areas of Dhi Qar Governorate, which are all generally located in the southern part of Iraq. The water samples were stored in sterile, transparent glass bottles, each of which had a uniform height and diameter, a base diameter of 5 cm, a top diameter of 2.5 cm, and a total height of 16 cm. These bottles were filled to the brim to ensure that they contained only river water. The river water samples were packaged in the form of granules, and the evaporation method was adopted to form the granules. After collecting the water samples in glass containers, they were placed in a special oven to evaporate the water, and then, the remaining granules were collected in the form of powder. These granules were used to measure boron pollution in river water using the CR-39 nuclear detector, and then sent to the laboratory for analysis.

2.2. Irradiation of samples

A nuclear detector (CR-39) which is a German-made (memmert) device was used.
Water samples in pellet form were coated with CR-39 detectors, and arranged on a paraffin wax plate. This assembly was positioned 5 cm from the neutron source, specifically an americium-beryllium (Am-Be) emitter. The Am-Be source was used because of its stable emission of thermal neutrons, with a flux measured at 5 × 〖10〗^3 n 〖cm〗^(-2) s^(-1). This setup is illustrated in (Figure.2).
Strategic positioning and shielding are critical to ensure that neutrons interact effectively with the samples, allowing for accurate measurements of boron concentration via the CR-39 detectors. This careful setup is essential to achieving accurate and reproducible results from well water sample analysis.

2.3. Chemical etching and scanning using a microscope

After exposure to radioactivity for seven days, the nuclear reaction formula below was used to explain the irradiation process performed on the samples, which is as follows:

$$10_B + n \rightarrow [11_B] \begin{cases} \nearrow\ 7_{Li} + 4_{He} \text{ +2.79 MeV(branching ratio 6.1\%)} \\ \searrow\ 7_{Li} + 4_{He} + 2.31 \text{ MeV(branching ratio 6.1\%)} \end{cases}$$

CR-39 reagents were extracted and subjected to chemical etching in a 6.25 ng NaOH aqueous solution, maintained at 60 °C for a standard period of 6 h, as described by Singh et al. (2001). After etching, the detectors are rinsed well with distilled water and left to air dry. The formation of the characteristic tracks on the CR-39 detectors was carefully documented using an optical microscope at

400x magnification. To measure the path density on the detectors, the following mathematical equation was used:

$$\rho = \frac{N\ average}{A}$$

In furtherance of the principles of CR-39 solid-state nuclear detectors (SSNTDs), a calibration curve was plotted against various standard boron solutions at concentrations ranging in mg/L. This calibration was critical to align our study and monitor density changes. Boron concentration was calculated using a regression equation that relates the track densities observed on sample detectors with those on reference samples. This equation represented as Y=5177+378.14, where the slope factor was confirmed after a linear calibration check. The results are interpreted in units of mg/L, as shown in (Figure.3), ensuring a comprehensive and accurate analysis of the boron concentration.

. Results

Boron levels were measured in 8 samples of Karmat Beni Said River water using the SSNTD technique. The results showed that all samples contained boron, as shown in (Table.1).

Table 1: Measurement of Boron Levels in Karma Bani Saeed River Water via SSNTD Technique

Sample Identifier	Location	Track density mm^2	Boron Concentration (mg/L)
R1	Karma Bani Saeed -1	6508.88	1.60
R2	Karma Bani Saeed -2	7507.40	1.80
R3	Karma Bani Saeed -3	7655.33	1.90
R4	Karma Bani Saeed -4	7285.50	1.80
R5	Karma Bani Saeed -5	5880.18	1.40
R6	Karma Bani Saeed -6	7137.57	1.70
R7	Karma Bani Saeed -7	7433.43	1.80
R8	Karma Bani Saeed -8	8025.15	1.95
		Average of concentration (1.74)	

Boron levels were measured in 8 samples of Al-Dawaya River water using the SSNTD technique, and the results showed that all samples contained boron, as shown in (Table.2).

Table 2: Measurement of Boron Levels in al-Dawayih River Water via SSNTD Technique

Sample Identifier	Location	Track density mm^2	Boron Concentration (mg/L)
R1	Al-Dawayih -1	9504.44	2.30
R2	Al-Dawayih -2	9023.67	2.20
R3	Al-Dawayih -3	10244.10	2.50
R4	Al-Dawayih -4	8616.86	2.11
R5	Al-Dawayih -5	8801.78	2.10
R6	Al-Dawayih -6	10244.10	2.50
R7	Al-Dawayih -7	10059.20	2.40
R8	Al-Dawayih -8	10503	2.60

4. discussion

(Table 1) shows the results of analyzing 8 samples from the river water stream of the Karma Bani Saeed area located south of Dhi Qar Governorate. The results showed that the boron concentrations in these samples ranged between 1.40 mg/L and 1.95 mg/L, with an average concentration of 1.74 mg/L. It is worth noting that the highest concentration of boron, which reached 1.95 mg/L, was found near the Karma Corniche, while the lowest concentration recorded was 1.40 mg/L, found near the Shatt Umm Nakhl area.

For Karma Beni Said locality, eight water samples were examined, designated as R1 to R8. Boron concentrations in this area showed a range from 0–1.4 mg/L to 1.95 mg/L. The observed values exceed the initial who guideline of 0.3 mg/L established in 1993 [12], and remain well above the revised guideline of 0.5 mg/L, which was provisionally set in 1998 [14], and later suspended pending further action. Research. However, these values are within the safety limits set by the European Union and New Zealand, indicated as 1.0 mg/L and 1.4 mg/L, respectively. Data indicate that the levels of boron concentration in Karma Beni Said water sources do not exceed current international standards that are considered safe for human consumption.

In contrast, (Table 2) shows details of the boron concentrations from another group of 8 water samples from the river water stream of the Ad-Dawaya area north of Dhi Qar Governorate, which were similarly analyzed using the CR-39 nuclear detector. The boron levels in these samples ranged more widely, from 2.10 mg/L to 2.60 mg/L, with an average concentration of 2.33 mg/L.

In the Douaya area, eight water samples labeled R1 to R8 showed boron concentrations ranging between 2.10 mg/L and 2.60 mg/L. These concentrations consistently exceed the outstanding WHO guideline of 0.5 mg/L, indicating the need to re-evaluate water treatment methods to ensure safety and compliance with international health standards. However, all measured values are below the Canadian

IMAC value of 5 mg/L, indicating an acceptable range according to Canadian standards, which are based on the practical limits of the processing technology.
Comparing the two regions within Dhi Qar Governorate, it becomes clear that the levels of boron concentration in Al-Duwayeh are higher than in Karma Bani Saeed. While both sites present concentrations above some international guidelines, they are within permissible limits in other areas, reflecting differing international standards and the importance of local water treatment strategies. It is essential that local authorities take into account current international guidelines, along with technological feasibility, to ensure the safety and health of populations that depend on these water resources.
The results underscore the need to periodically review water quality and modify treatment protocols as new data emerges and technological advances are made. This approach is consistent with the Canadian perspective, which expects regular updates to IMAC values in response to emerging research and technological innovations.
The pollution of river water with boron may be attributed to the excessive use of fertilizers and pesticides containing boron, which leads to the leakage of these materials into the river water, especially during irrigation or rainfall, considering that Dhi Qar Governorate is an agricultural governorate. The difference in the percentage of boron pollution along the course within the same region is due to the difference in the percentage and times of use of fertilizers and pesticides from one region to another.
Studies in this area are also rare, which increases the importance of the results of this research.

CONCLUSION

The results of this study confirm the presence of boron contamination in the river water in Dhi Qar-Iraq, as the analyses showed that all samples examined from different areas along the river were contaminated with this element. These results are of great importance in terms of potential impacts on public health and environmental safety. Providing this information can help support the efforts of the government and relevant institutions in making appropriate decisions to improve water quality and reduce pollution, which contributes to improving public health and the environment in the region.

Funding
This research received no external funding or grants.

Conflict of interest
Authors state no conflict of interest.

Ethics Committee

The minutes of the Ethics Committee were approved.

References

[1]. Buonomenna, M. G., Mousavi, S. M., Hashemi, S. A., & Lai, C. W. (2022). Water cleaning adsorptive membranes for efficient removal of heavy metals and metalloids. Water, 14(17), 2718.

[2]. Wolska, J., & Bryjak, M. (2013). Methods for boron removal from aqueous solutions—A review. Desalination, 310, 18-24.

[3]. Begg, E. J., Barclay, M. L., & Duffull, S. B. (1995). A suggested approach to once-daily aminoglycoside dosing. British journal of clinical pharmacology, 39(6), 605-609.

[4]. Mohamed, A. A., & Al-Khalifa, I. J. (2015). Boron concentration measurements in Thiqar Governorate rivers by using curcumin method. Archives of Applied Science Research, 7(2), 5-8.

[5]. Al-Ibrahimi, J. H. M., & Al-Asadi, A. D. K. (2023). Effect of potassium, trace elements and cultivar on some physiological traits and sugars at the khalal stage of fruits of date palm (phoenix dactylifera L.) grown in Thi-Qar governorate. University of Thi-Qar Journal of agricultural research, 12(1), 112-129

[6]. Salman, T. M., & Jafer, M. M. The Estimated of Boron Concentration in Water Samples of the north of Basrah Governorates Using AAS Techniques. International Journal of Engineering and Applied Sciences, 5(1), 257296.

[7]. Habeeb, A. F., & SALMAN, T. M. ESTIMATION THE CONCENTRATION OF BORON IN THE WATERS OF PARTS OF IRAQI MARINE ENVIRONMENT USING SSNTDS (CR-39) TECHNIQUE.

[8]. Hadi, W. S., Salman, R. S., Al-Fahham, A. A., Khan, M. U. F., Kadir, S., Laft, M. H., ... & Kadhim, M. M. (2022). Evaluation of IL-17 and IL-35 in patients with giardiasis in Thi-Qar province, Iraq. Journal of Medicine and Life, 15(9), 1096-1099.

[9]. Alzrgani, M. S. M., & Khrbeet, H. K. H. (2021). Effect of Foliar Application of Boron on Growth Yield and Yield Components of Four Varieties of Oats Avena sativa L. Jornal of Al-Muthanna for Agricultural Sciences, 8(4).

[10]. Salman, T., & Shaker, T. (2015). The measurements of boron concentration rate in soils of Dhi-Qar Governorate (in Iraq) Using Carmine method. Journal of Basrah Researches (Sciences), 41.

[11]. Algrifi, M. A., & Salman, T. M. (2022). Measurements of boron concentration from rivers in northern Basrah Governorate using SSNTDs. *Water Supply*, *22*(4), 4584-4593.

[12]. Singh, J., & Singh, N. (2001). Studies on the morphological, thermal and rheological properties of starch separated from some Indian potato cultivars. *Food chemistry*, *75*(1), 67-77.

[13]. Salman, T. M., & Jafer, M. M. Boron Concentration in Water Samples Of North Basrah Governorate (Iraq) Using Carmine Method.

[14]. Yazbeck, C., Kloppmann, W., Cottier, R., Sahuquillo, J., Debotte, G., & Huel, G. (2005). Health impact evaluation of boron in drinking water: a geographical risk assessment in Northern France. Environmental geochemistry and health, 27, 419-427.