Journal of Basrah Researches (Sciences) **51**(1), 99 (2025)
DOI https://doi.org/10.56714/bjrs.51.1.8

The Radioactivity Monitoring of Drinking Water Consumed in the Northern Basrah Governorate, Iraq, Using TLD-200

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ARTICLE INFO

Received 9 January 2025
Revised 5 March 2025
Accepted 6 March 2025
Published 30 June 2025

Keywords:

Gamma Radiation; Thermoluminescence; Drinking Water; Basrah Governorate

Citation: Z. H. Ahmed, A. Al-Salihi,J.Basrah Res. (Sci.) **51**(1),99 (2025). DOI:https://doi.org/10.56714/bjrs.51.1.8

ABSTRACT

Nine drinking water samples of different stations were collected from Northern Basrah governorate. The radioactivity assessment of drinking water was achieved by using thermoluminescence technique applying calcium fluoride dysprosium dosimeters (TLD-200). The lowest values of gamma absorbed dose was 0.0001 mSv/y, while the maximum result of gamma absorbed dose 0.021 mSv/y. Annual effective dose equivalent and excess lifetime cancer risk have been calculated for all drinking water samples. All outcomes have been recorded to be lower than the standard values. Thus, drinking water samples of different stations are harmless to be consumed in Northern Basrah city.

1. Introduction

Water pollution is any physical or chemical modification to the quality of water that happens either directly or indirectly and affects water quality, making it unhealthy for human consumption [1, 2]. According to the World Health Organization, the term "drinking water" refers to water that is suitable and safe for drinking [3].

Radioactive pollution does not cause any change in the natural characteristics of water as it is mostly absorbed by the organisms present in this water and then transmitted to humans while consuming these organisms, causing many dangerous effects, including defects and transformations that occur in genetic genes. Therefore, knowing the extent of its danger to humans and other living organisms is done by what is called radiation dosimetry, which means measuring the absorbed dose or other relevant quantities [4-7]. An adaptable technique for assessing the dosage of ionizing radiation is thermoluminescence dosimetry (TLD). Radiation exposure causes the TL material to absorb energy, which is then stored until it is excited by heat. The TL glow curve presents how much light is emitted as a function of temperature. To a few grays, the majority of TL dosimeters

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ISSN: 1817-2695 (Print); 2411-524X (Online)
Online at: https://jou.jobrs.edu.iq

show a linear response to dosages [8-11]. The radioactivity of drinking water in many international universities has been extensively studied [12-16]. This study focused on drinking water stations that are often used by different age groups in Northern Basrah, Iraq. The Iraqi government must regulate the local drinking water to ensure that it is free of radioactive contamination. This study is vital for assessing the risk of radioactivity to humans and for developing policies and guidelines related to radiation safety. It is essential for figuring out how much radiation the Iraqi people are exposed to. This is due to the fact that excessive radiation exposure can lead to serious health issues like cancer [17]. For this reason, it is important to conduct this study. For the purpose of tracking radiation risks to human health, it is essential to measure the radiation dose in drinking water [12, 18, 19]. This scientific research aims to create a map of radiological data regarding the radiation risks in drinking water. To achieve this, it is critical to compute and investigate the radioactivity and radiation risk indices of the drinking water stations that are located in northern Basrah, Iraq.

2. Data Collection

As indicated in Table 1, nine samples of drinking water were chosen, and all of the samples were subsequently gathered from various sites in the northern Basrah governorate. This study took place over the course of three months, from August 2024 to November 2024.

Table 1. Sample information

Sample code	Sample volume (liter)	Sample location
W1	60	AL-Nuhirat /Qurnah/Basrah
W2	60	Center of Qurnah/Basrah
W3	60	AL-Hamdawy/Qurnah/Basrah
W4	60	AL- Naiem/ Qurnah/Basrah
W5	60	Sadt Kamesa/Qurnah/Basrah
W6	60	AL-Dear / Qurnah/Basrah
W7	60	AL- Sadeq / Mdaina/Basrah
W8	60	Ice plant/ Qurnah /Basrah
W9	60	Center of Mdaina / Basrah

A plastic beaker was filled with 60 liters of drinking water. In the center of the filled beaker were three annealed TLD-200 dosimeters. To gather a sufficient quantity of gamma radiation, labeled beakers were stored in the Thermoluminescence Laboratory before the measurement [20-22].

3. Measurement Methods

The Harshaw model 2000 B/C reader is used in the current work. One of the basic components of TL reader is a planchet (pan) for locating and heating the TL dosimeter. In this research, preset the planchet temperature of (100^{o}C) at which integration begins whereas to the planchet temperature of (300^{o}C) at which integration stops.

The thermoluminescence (TL) approach was used to measure the water consumption samples using dosimeters of CaF2:Dy (TLD-200). The lower detection limit (D_{ldl}) of TLD-200 equals to 0.3 (arbitrary units). The TLD-200's calibration equation is shown as [23] :

$$D_X = \left(\frac{\overline{M}_x - \overline{B}}{\overline{M}_c - \overline{B}}\right) D_C \quad (1)$$

The unknown dose D_x is the water drinking sample dose, the quantity M_X is the average reading of subgroup of TLDs (normally three dosimeters in each water sample) that were in a water sample. The zero dose reading of each TLD ($\overline{B}$: the background of TLD), D_C (calibration dose) = 64 mrad and the magnitude of average reading related to the calibration dose $\overline{M}_C - \overline{B} = 118.684$ (arbitrary units). The light emission acquired during the TLD readout is converted to the absorbed dosage (D_X) of the water drinking sample using Equation1 [23].

3.1 Annual effective dose equivalent

These formulas are used to determine the indoor and outdoor of AEDE [24]:

$$AEDE_{outdoor}(\frac{msv}{y}) = dose(D)\times 8760\times conversion(0.7)\times occupancy(0.2\times 10^{-6}) \tag{2}$$

$$AEDE_{indoor}(\frac{msv}{y}) = dose(D)\times 8760\times conversion(0.7)\times occupancy(0.8\times 10^{-6}) \tag{3}$$

Where: D is absorbed dose rate measured in nGy/h. The first factor is called the conversion factor of 0.7 Sv/Gy. The second factor is called the occupancy factor is 0.8 and 0.2 for indoor and outdoor respectively, since people spend approximately 80% of their time indoor and 20% outdoor [24].

3.2 Excess lifetime cancer risk

The following factors might be taken into consideration when evaluating the excess lifetime cancer risk, which is caused by gamma radiation effects: [9, 25]:

$$ELCR = AEDE\times DL\times RF \tag{4}$$

In this case, AEDE, DL, and RF stand for annual effective dosage, standard age (70 years), and risk factor, respectively. As advised by the ICRP for stochastic impacts, the public's risk factor is 0.05 per Sievert. [25, 26].

4. Results and Discussion

As illustrated in Table 2 and Figures 1 and 2, the absorbed dose ranges for all water samples determined by the TL approach (using equation 1) were 0.0161 **nGy/h** and 2.766 **nGy/h**, with averages of 1.206 ± 0.656. The outcomes obtained appear to be smaller than the standard acceptable limit dose rates. The accepted standard limit dose rates of 58 nGy/h mentioned in UNSCEAR 2000 [24]. For every water sample, the TL approach was used to calculate the excess lifetime cancer risk (ELCR) and annual effective dose equivalent (AEDE) values for both indoor and outdoor gamma exposures. Equations 2, 3, and 4 were used to perform the mathematical computations of these data. The ranges of $AEDE_{outdoor}$, $AEDE_{indoor}$, $ELCR_{outdoor}$ and $ELCR_{indoor}$ measured by TL technique were (0.0002 and 0.003) mSv/y, (0.0001 and 0.012) mSv/y, (0.001 and 0.010) and (0.0003 and 0.040) with averages of (0.001±0.001) mSv/y, (0.005±0.003) mSv/y, (0.004±0.002) x10^{-3} and (0.018±0.010) x10^{-3} respectively as demonstrated in Table 2 and Figures1 and 2.

Table 2. Gamma absorbed dose (D), annual effective dose equivalent (AEDE), and excess lifetime cancer risk (ELCR) are measured using the TL technique

Sample code	D(nGy/h)	AEDE (mSv/y)		ELCR×10^{-3}	
		Outdoor	Indoor	Outdoor	Indoor
W1	1.170	0.001	0.005	0.004	0.017
W2	0.0161	0.00002	0.0001	0.0001	0.0003
W3	1.072	0.001	0.004	0.004	0.016
W4	2.766	0.003	0.012	0.010	0.040
W5	1.190	0.001	0.005	0.004	0.017
W6	1.211	0.001	0.005	0.004	0.018
W7	1.128	0.001	0.005	0.004	0.016

W8	1.162	0.001	0.005	0.004	0.017
W9	1.139	0.001	0.005	0.004	0.017
MIN	0.0161	0.00002	0.0001	0.0001	0.0003
MAX	2.766	0.003	0.012	0.010	0.040
Average±SD	1.206 ± 0.656	0.001±0.001	0.005±0.003	0.004±0.002	0.018±0.010

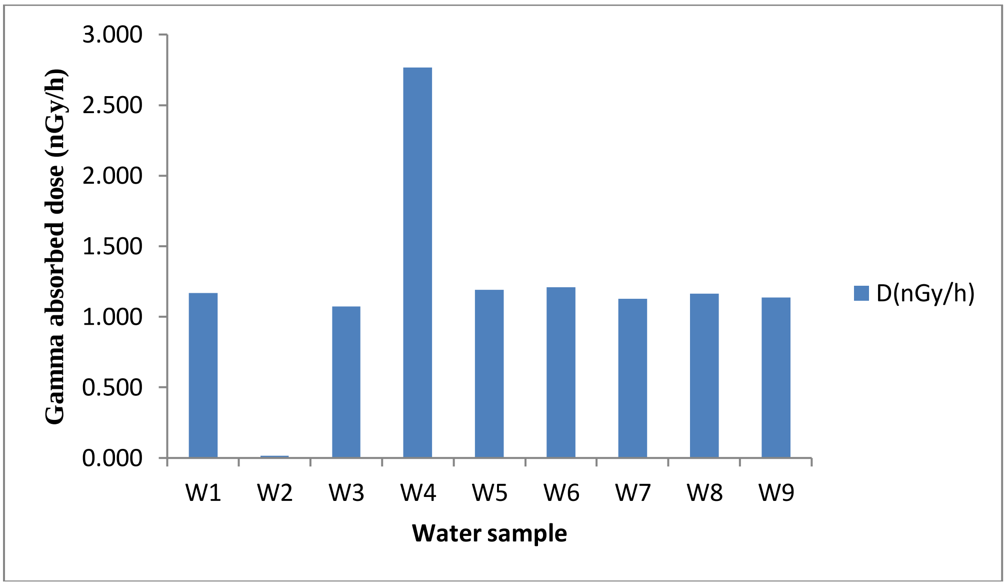

Fig.1. Gamma absorbed dose (D) is measured using the TL technique

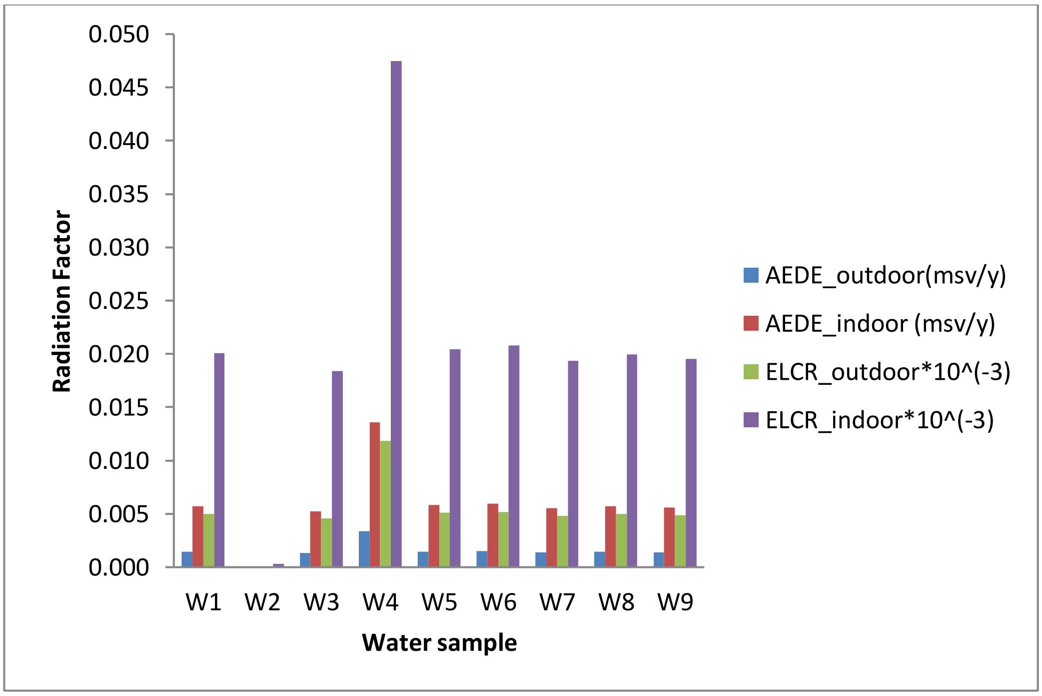

Fig.2. Annual effective dose equivalent (AEDE), and excess lifetime cancer risk (ELCR) are measured using the TL technique

All water samples seem to have AEDE and ELCR readings below the allowable range. UNSCEAR 2000 recommended that the world average outdoor and indoor annual effective dosage equivalent be 0.07 mSv/y and 0.34 mSv/y, respectively. UNSCEAR 2000 reports the agreed global average $ELCR_{outdoor}$ of 0.29 × 10-3 and $ELCR_{indoor}$ of 1.4 × 10-3 [24, 26]. The findings from different stations show very little variation. This means that water drinking in northern Basrah stations is almost the same source except sample coded as W4.

5. Conclusion

All samples were analysed for excess lifetime cancer risk values, absorbed dose rates, and yearly effective dose equivalent values. The results indicate that there is no radiation risk associated with the drinking water drank in the northern Basrah, Iraq. In order to establish baseline data on drinking water use for the creation of a radiological map of Basrah, Iraq, the current study suggests that other drinking water stations should conduct comparable studies.

Acknowledgment

All those who helped to declare this issue are acknowledged by the authors. We would especially want to thank the academic staff at the University of Basrah/ College of Education for Pure Sciences/ Department of Physics.

Conflict of Interest

No conflicts of interest are disclosed by the authors.

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Journal of Basrah Researches (Sciences) **51**(1), 99 (2025)
DOIhttps://doi.org/10.56714/bjrs.51.1.8

مراقبة النشاط الإشعاعي لمياه الشرب المستهلكة في شمال محافظة البصرة ، العراق، باستخدام تقنية التالق الحراري

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معلومات البحث

الاستلام 9 كانون الثاني 2025
المراجعة 5 اذار 2025
القبول 6 اذار 2025
النشر 30 حزيران 2025

الكلمات المفتاحية

أشعة كاما؛ التالق الحراري؛ مياه الشرب؛ محافظة البصرة.

الملخص

تم جمع تسع عينات من مياه الشرب من محطات مختلفة في شمال محافظة البصرة. تم تقييم النشاط الإشعاعي لمياه الشرب باستخدام تقنية التالق الحراري بتطبيق كواشف فلوريد الكالسيوم المشوبه الديسبروسيوم (TLD-200). أدنى قيمه لجرعة الامتصاص من أشعة كاما كانت ٠,٠٠٠١ مللي سيفرت/سنة، بينما كانت أعلى قيمة لجرعة الامتصاص من أشعة كاما ٠,٠٢١ مللي سيفرت/سنة. تم حساب الجرعة الفعالة السنوية المكافئة ومعامل خطر الإصابة بالسرطان لجميع عينات مياه الشرب. تم تسجيل جميع النتائج بأنها أقل من القيم القياسية. لذا، فإن عينات مياه الشرب من محطات مختلفة آمنة للاستهلاك في شمال محافظة البصرة.

Citation: Z. H. Ahmed, A. Al-Salihi,J.Basrah Res. (Sci.) **51**(1),99 (2025). [DOI:https://doi.org/10.56714/bjrs.51.1.8](https://doi.org/10.56714/bjrs.51.1.8)

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ISSN: 1817-2695 (Print); 2411-524X (Online)
Online at: https://jou.jobrs.edu.iq