



Natural radioactivity and radiological risk in cow's milk consumed in Iraq

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Article information

Article history:

Received July 25, 2025
Accepted December 3, 2025
Published July 5, 2026

Keywords:

Animal
Public health
Radionuclides
Milk
Contamination

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Abstract

Animal public health problems have spread increasing concern in the radiological safety of milk products. The level of occurring radionuclides—Radium-226 (Ra^{226}), Thorium-232 (Th^{232}), and Potassium-40 (K^{40})—in cow's milk samples collected from 18 provinces in Iraq and the corresponding radiological health risk are examined herein. Radioactivity levels were quantified in units of Bq/L, from which the significant hazard indicators like radium equivalent activity ($Raeq$), absorbed dose rate (D), annual effective dose equivalent ($AEDE$), excess lifetime cancer risk ($ELCR$), and hazard indices (Hex , Hin , Iy) were determined. Results revealed significant spatial variation in radionuclide concentrations, where K^{40} exhibited the maximum values for all samples. Basrah registered the highest values for Ra^{226} , Th^{232} , and K^{40} and also reported the maximum $Raeq$ (8.17 Bq/L), D (4.16 nGy/h), $AEDE$ (5.11 μ Sv/y), and $ELCR$ (17.87×10^{-3}). All the calculated radiological parameters were observed less than international safety standards, though Basrah, Babylon, and Al-Samawah still displayed higher values. Overall, Stacked radiological indicator visualization and $ELCR$ validation witnessed a clear segregation of increased exposure in southern regions. Despite adequate safety margins, aggregated risk illustrated by $ELCR$ and hazard indices demonstrate the need for ongoing monitoring, especially in those regions at greater risk. The importance of this research lies in obligating factory and farm owners to monitor these products periodically and to adhere to the permissible limits according to national and international standards in a way that guarantees the safety of the product.

DOI: [10.33899/ijvs.2025.165775.4540](https://doi.org/10.33899/ijvs.2025.165775.4540), ©Authors, 2026, College of Veterinary Medicine, University of Mosul.
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Introduction

Milk constitutes a major component of the Iraqi diet, taken daily by millions and perceived as a source of vital proteins, vitamins, calcium, and other nutrients (1). Among all foods of animal origin, cow's milk is singular, especially in rural areas where fresh milk constitutes the principal staple in the diet (2). However, the nutritional value of milk can be compromised through contamination, most notably with environmental pollutants such as radionuclides (3). In war-torn countries such as Iraq, one of the more important future

public health threats is radioactive contamination of agri-products and livestock products not because of fertilizers or natural background radiation but from extensive military operations and war-related environmental pollution (4). Unlike many countries where natural background radiation or agricultural practice might be the dominant sources of contamination, Iraq is an exception (5). Since the 1991 Gulf War, and more deeply after the 2003 invasion and constant wars, Iraq has experienced prolonged environmental stress from the use of depleted uranium (DU) weapons, bombing of military and industrial installations, burning of oil wells,

and demolishing of infrastructure (6). These activities have contributed to the release and redistribution of radionuclides, including Radium-226 (Ra-226), Thorium-232 (Th-232), and Potassium-40 (K-40), into the Iraqi environment (7). These toxins persist in surface water, soils, and forage, and could accumulate biologically in livestock, especially grazing dairy cows or consuming contaminated feed and water. From a veterinary public health perspective, this is a cause for concern (8). The health of farm animals that produce food is not just a matter of agricultural productivity and animal farm welfare but also a critical part of public health in that cattle are not only sentinels but also carriers for environmental hazards (9). Cows, if they consume contaminated water or radionuclide-contaminated pastures, metabolize the elements, which can be passed to their milk (10). This is an important pathway for internal exposure in individuals public health, in particular children and pregnant women who are more vulnerable to radiation damage. Long-term exposure to radionuclides also affects animal health, decreasing fertility, immunity, and milk yield, further jeopardizing food security and rural livelihoods. Ra-226, whose chemical similarity to calcium gives it a propensity to bind to bone very tightly and emit alpha radiation over many years, increasing the chances of bone cancer and leukemia (10). Th-232, though fixed, emits high-energy alpha particles and gamma radiation with a half-life of 14 billion years and is reported to cause liver and lung toxicity. K-40, which is a naturally occurring radioactive isotope, generates much of the internal background radiation but can become dangerous when concentration levels get higher than usual ranges due to environmental disturbance. Whereas every nation has a stake in the radiological safety of food, that of Iraq is special. The environmental record of military operations especially the widespread use of weapons using DU—has established spot concentrations of radioactivity that endure for decades. Investigations in Basra, Fallujah, and Mosul areas have reported high cancer rates and birth defects, along with other health impacts of radiation among human beings as well as animals. The impacts might be under-reported or misdiagnosed due to insufficient environmental and veterinary monitoring capability. No national common system exists currently for food products, like milk, monitoring for radionuclide content in Iraq. The gap poses a very dangerous threat to veterinary public health and consumer safety (11). The veterinary component of radioactive contamination is often underestimated. Animals are, however, among the first to feel the impacts of environmental alterations, and their exposure can be utilized in predicting risks to human health. In Iraq, grazing dairy cows in radiated soil, consuming unsecured water, or eating radiologically untested imported feed represents an uncontrolled risk to the food supply. Economic value in the production of dairy adds to the problem. Health of cattle declining as a consequence of exposure to radiation can lead to increased veterinary

spending, reduced productivity, and decrease earnings for smallholder farmers specially in post-conflict and insecure areas. In these contexts, veterinary public health has two functions: protecting the health of animals as a moral and economic imperative, and preventing the transmission of environmental risk from animals to humans. This falls under the One Health approach, which recognizes the relationship between human, animal, and environmental health. Radioactive monitoring of cow's milk should therefore be considered not just as a food security issue but also as a veterinary public health issue in post-war Iraq. The current study was set to assess the levels of Ra-226, Th-232, and K-40 in cow's milk samples collected from various regions of Iraq. These radionuclides were selected based on their previously reported presence in military-contaminated zones and biological relevance in humans and animals. Each radionuclide concentration was measured using gamma spectrometry, and their potential health risks were assessed by the annual effective dose (AED), excess lifetime cancer risk (ELCR), and hazard index (HI) for human milk consumers. As well as, the project also considers the broader implications for animal production and public health contamination in environments (12). In general, examining milk not only protects the consumer but also provides valuable information on environmental safety, exposure of animals, and the general ecological impact of war. Most previous radiological studies in Iraq have focused on endpoints in soil, water, or human health. Few have discussed veterinary pathways through which radionuclides enter the food chain, and assessed the potential long-term health implications for animals and milk safety. By focusing on cow's milk a critical, ubiquitous food this study contributes more fully to an understanding of Iraq's environmental health profile and supports the development of risk-based monitoring and intervention programs.

Finally, this study emphasizes the need for national radiological food safety policy, especially in the veterinary public health (13). Contamination of milk with radionuclides such as Ra-226, Th-232, and K-40 introduced not by fertilizers or natural background radiation but by war and military conflict and attendant pollution—raises a serious threat both to animal health and human health (14). The aim of the project is to quantitatively determine radionuclide contamination in milk samples from various regions of Iraq with respect to determining radiological risk levels, geographical hotspots, and possible pathways of exposure via the consumption of dairy products. This project should provide scientific data that enhances food safety surveillance systems, informs radiation protection policy, and underpins the protection of public health and the sustainable recovery of the environment in post-conflict Iraq.

Materials and methods

Ethical approval

This study was reviewed and approved by the Institutional Animal Care and Use Committee, University of Mosul, College of Veterinary Medicine (Ref: UM.VET.2025.080, Date: 2/1/2025). All the procedures on experimental animals were conducted under approved guidelines of ethics.

Sample collection

A total of 18 cow's milk samples were randomly collected from across 18 provinces in Iraq, 10 samples per province to give a spatially representative sample, in order to ensure spatial and statistical representativeness. Sampling sites included the northern, central, and southern regions, reflecting variable climatic, agricultural, and potential radiological exposure conditions related to past military activities. Sampling took place between January and February 2025, which is a typical period for dairy production. About 500 mL of milk was collected directly from local dairy farms and family producers in sterile polyethylene containers. The samples were kept in ice boxes at a temperature of 4 ± 2 °C to prevent spoilage and were sent to the laboratory within 24 hours. Upon arrival, they were homogenized and kept at a temperature of -20 °C until the time of radionuclide analysis. (15).

Sample preparation

Milk samples were first thawed at room temperature and made uniform in temperature before analysis. The samples were mixed well and poured into standard Marinelli beakers (1 liter capacity), dried at 100 °C to remove water content where necessary, and sealed with parafilm to avoid contamination or loss of volatiles (16). Sealed samples were left undisturbed for a period of not less than 24 hours for secular equilibrium between parent and daughter radionuclides.

Gamma spectroscopy analysis

Quantitative determination of the radionuclides (Ra^{226} , Th^{232} , and K^{40}) in milk samples was made by using the HPGe gamma-ray spectrometry for high-resolution detection. The system consisted of a coaxial HPGe detector (40% relative efficiency, 1.8 keV FWHM at 1332 keV, Canberra Industries) coupled with a multichannel analyzer and operated via the GENIE 2000 software for spectral acquisition and isotope identification (17). The detector was encased in a 10 cm lead shield to minimize background radiation. Efficiency calibration was performed with matrix-matched reference standards (IAEA-152 milk powder) and also tested against Cs-137, Co-60, and K-40 point sources. Each sample of milk (~500 mL) was measured in standard

Marinelli geometry for 3600 s to reach sufficient counting precision (18). Daily background spectra were recorded and subtracted from sample counts. Uncertainties are given at the 1σ level of confidence, and MDA values were calculated according to Currie's method, taking care to ensure the reliability of measurements of low activities (19).

Quality control and assurance (20)

Annual Effective Dose (AED)

$$AED = A \times IR \times DC \times 365$$

Where: A is the activity concentration (Bq/L), IR is the ingestion rate (0.25 L/day for adults, 0.5 L/day for children), DC is the dose conversion factor (Sv/Bq) for each radionuclide (from ICRP 119).

Excess Lifetime Cancer Risk (ELCR)

$$ELCR = AED \times LE \times RF$$

Where: LE is life expectancy (70 years), RF is risk factor (0.05 Sv^{-1}) for stochastic effects as recommended by ICRP.

Hazard Index (HI)

Calculated as a sum of dose fractions of all the radionuclides, used to assess overall safety.

Statistical analysis

Descriptive statistics were computed for all radionuclide concentrations to summarize the distributional trends. Prior to conducting any type of parametric analysis, normality assumptions for the data were checked using the Shapiro-Wilk test (21). One-way ANOVA was conducted among provinces while Pearson's correlation tested the interrelationship between the radionuclides. Geostatistical mapping and spatial interpolation had been implemented by ArcGIS 10.8 using the IDW method, showing regional variations in element contents and contamination hotspots. All analyses have been done using SPSS version 26, taking $\alpha = 0.05$ as the level of significance.

Results

A total of 18 samples of cow's milk were gathered from various provinces in Iraq to evaluate the occurrence and variation of natural radionuclides—namely Radium-226 (Ra^{226}), Thorium-232 (Th^{232}), and Potassium-40 (K^{40}) and calculate related radiological health hazards based on internationally accepted hazard indices (Figure 1).

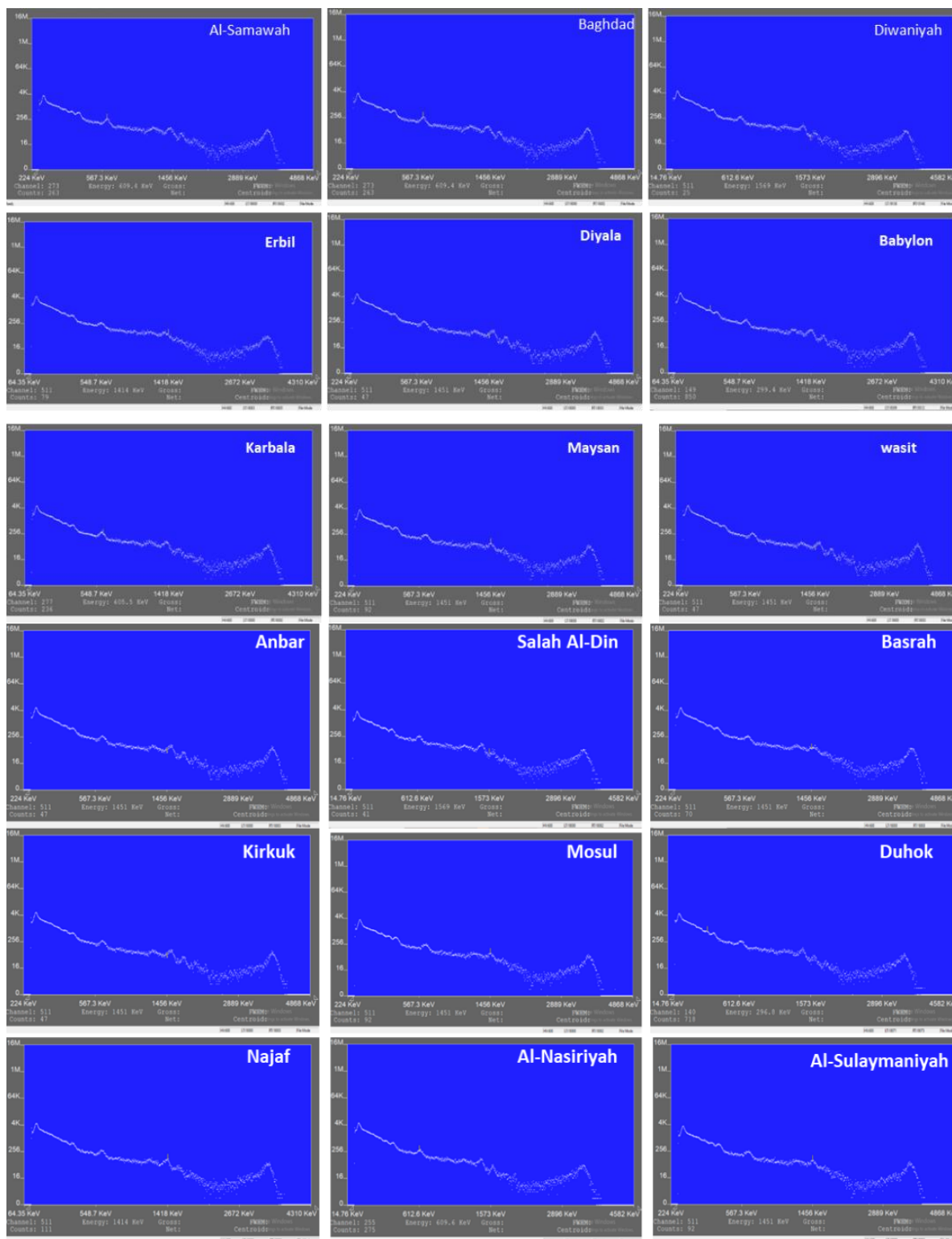


Figure1: Gamma-ray spectra of cow's milk samples from Iraqi provinces gathered by using high-purity germanium (HPGe) detectors. Various peaks detect natural radionuclides like Ra^{226} , Th^{232} , and K^{40} with variations in counts and energy ranges between provinces.

Radioactivity concentrations

Concentrations of ^{226}Ra , ^{232}Th , and ^{40}K (in Bq/L) showed significant variation among the provinces (Table 1). Activity concentrations of ^{226}Ra varied from 0.454 Bq/L (Kirkuk) to 1.050 Bq/L (Basrah). Correspondingly, ^{232}Th varied from 0.447 Bq/L (Kirkuk) to 1.152 Bq/L (Basrah). In the case of ^{40}K , a wide range was noted, with values ranging from 11.64 Bq/L (Diyala) to 79.04 Bq/L (Basrah), and indicating the share of potassium-based radioactivity in the southern areas. In contrast, provinces like as Babylon, Duhok, and Al-Sulaymaniyah also illustrate that elevated levels of ^{40}K (greater than 30 Bq/L), while most central and northern provinces exhibited lower concentrations of all three isotopes. These spatial disparities may reflect heterogeneous environmental, agricultural, and geological conditions influencing the radionuclide content in the local milk (Figure 2 and 3).

Table1: Radionuclides levels of milk samples for Radium-226 (^{226}Ra), Thorium-232 (^{232}Th), and Potassium-40 (^{40}K)

Iraqi's Province	Ra226 (Bq/L)	Th232 (Bq/L)	K40 (Bq/L)
Al-Samawah	0.899	1.086	32.03
Al-Nasiriyah	0.508	0.532	14.59
Baghdad	0.575	0.819	17.81
Babylon	0.962	0.829	45.23
Karbala	0.735	0.856	15.43
Anbar	0.653	0.857	14.92
Salah Al-Din	0.706	0.807	17.01
Basrah	1.05	1.152	79.04
Kirkuk	0.454	0.447	17.26
Mosul	0.692	0.777	13.51
Duhok	0.586	0.673	40.64
Najaf	0.827	0.893	17.21
Maysan	0.877	1.105	23.85
Diyala	0.937	0.615	11.64
Erbil	0.476	0.589	27.36
Al-Sulaymaniyah	0.455	0.669	32.6
Diwaniyah	0.946	0.837	12.17
Wasit	0.598	0.764	26.02

Calculated radiation hazard indicators

To evaluate the public health effects of the calculated concentrations of radionuclides, some radiological indices were computed. These include Radium Equivalent Activity (Raeq), Absorbed Gamma Dose Rate (D), Annual Effective Dose Equivalent (AEDE), Excess Lifetime Cancer Risk (ELCR), and hazard indices for external (H_{ex}) and internal (H_{in}) exposure, and the gamma representative index (I_{γ}). The Raeq ranged from 2.64 Bq/L in Al-Nasiriyah to 8.172 Bq/L in Basrah. They were all much lower than the

international reference level of 370 Bq/L, indicating low total combined activity.

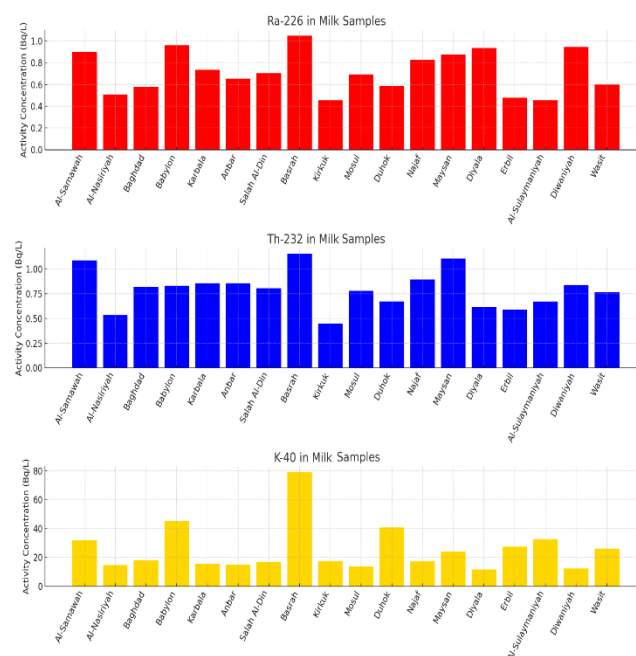


Figure 2: Comparison of histograms showing the radionuclide activity concentrations (^{226}Ra , ^{232}Th , and ^{40}K) in cow's milk samples from 18 different Iraqi provinces. All plots use the same scale for the Y-axis—that of ^{40}K —for ease of comparison; this also displays the prevalence of the naturally occurring potassium isotope, ^{40}K , over the trace levels of ^{226}Ra and ^{232}Th throughout different regions.

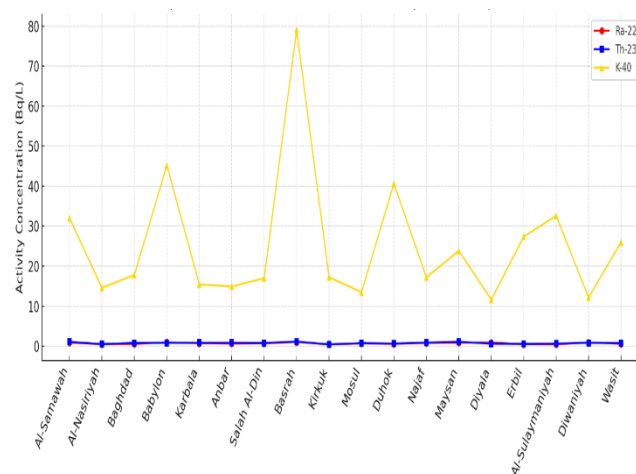


Figure 3: Comparison levels of Radionuclides from milk samples across Iraqi provinces.

The absorbed dose rate (D) thus ranged from 1.256 to 4.163 nGy/h, the highest again being in Basrah. These dose rates are far below the world average of 55 nGy/h for natural background radiation. The AEDE, calculated to represent the internal dose via milk consumption, varied from a low of 1.540 μ Sv/y (Diyala) to a high of 5.106 μ Sv/y (Basrah). A broader estimate for effective dose (μ Sv/y)), which can represent more general ingestion scenarios, followed a similar trend, with values spanning from 8.901 μ Sv/y to 30.579 μ Sv/y. Basrah represented the highest dose in both measures, as might be anticipated from its high radionuclide content. The ELCR, a probabilistic estimate of carcinogenic risk over a lifetime, ranged from 5.393×10^{-3} in Diyala to

17.873×10^{-3} in Basrah. Though within internationally acceptable limits, their relative high levels in some provinces call for diligent surveillance and precautionary measures. For hazard indices, all samples fell below the unity level for Hex, Hin, and I γ , which are safe based on ICRP and UNSCEAR recommendations. The highest external hazard index (Hex = 0.0220), internal hazard index (Hin = 0.0246), and gamma index (I γ = 0.0331) were again noted in Basrah, indicating the same pattern of higher radiological load in that region. Other provinces that were relatively higher in their indices included Babylon, Al-Samawah, and Maysan, whereas Al-Nasiriyah, Diyala, and Kirkuk were consistently lower across the range (Table 2).

Table 2: Hazard Indicators levels of effects for milk samples levels of radiations

Iraqi's Province	Ra _{eq} (Bq/L)	D (nGy/h)	(μ Sv/y)	(μ Sv/y)	ELCR $\times 10^{-3}$	Hex	Hin	I γ
Al-Samawah	4.693	2.313	2.837	16.743	9.932	0.0126	0.015	0.0183
Al-Nasiriyah	2.64	1.28	1.57	9.198	5.495	0.0071	0.0086	0.0101
Baghdad	3.255	1.58	1.937	11.362	6.782	0.0087	0.0105	0.0125
Babylon	5.719	2.86	3.508	20.828	12.278	0.0154	0.0179	0.0227
Karbala	3.167	1.515	1.858	10.826	6.505	0.0085	0.0104	0.012
Anbar	3.149	1.491	1.829	10.587	6.402	0.0085	0.0107	0.0117
Salah Al-Din	3.506	1.689	2.071	12.134	7.251	0.0094	0.0111	0.0134
Basrah	8.172	4.163	5.106	30.579	17.873	0.022	0.0246	0.0331
Kirkuk	2.776	1.363	1.672	9.852	5.853	0.0074	0.0089	0.0108
Mosul	2.712	1.29	1.582	9.184	5.537	0.0073	0.0091	0.0101
Duhok	4.889	2.483	3.045	18.215	10.659	0.0132	0.0147	0.0197
Najaf	3.333	1.588	1.947	11.317	6.817	0.009	0.0111	0.0125
Maysan	3.987	1.918	2.352	13.724	8.235	0.0107	0.0132	0.0151
Diyala	2.633	1.256	1.54	8.901	5.393	0.0071	0.0095	0.0098
Erbil	3.357	1.687	2.069	12.327	7.242	0.009	0.0102	0.0134
AlSulaymaniyah	4.187	2.103	2.58	15.366	9.03	0.0113	0.0128	0.0167
Diwanayah	3.013	1.432	1.756	10.189	6.149	0.0081	0.0102	0.0113
Wasit	3.846	1.896	2.325	13.733	8.138	0.0103	0.0121	0.015

The overall impression from the data is that while most of the milk samples from throughout Iraq are within safe radiological limits, provinces such as Basrah, Babylon, and Al-Samawah have consistently elevated radionuclide concentrations and radiological risk indices. These findings call for localized radiological surveillance and further investigation of environmental determinants of regional differences in milk contamination levels. Targeted mitigation efforts and public information campaigns may be warranted in regions of higher risk to safeguard long-term food safety and public health.

Discussion

Radiological analysis of cow milk collected from 18 provinces across Iraq revealed remarkable variation in the concentrations of naturally occurring radionuclides and

associated health hazard pointers. Variation among levels of Ra 226 , Th 232 , and K 40 are attributed to the provinces' environmental heterogeneity, together with potential anthropogenic effects (22). Of these, K 40 achieved the highest values in all samples, in line with its biological demand and natural abundance (23,24). Most significantly, Basrah recorded the highest value of 79.04 Bq/L, followed closely by Babylon and Duhok. High values of potassium in these provinces may be because of soil texture, animal feed, or aquifer properties with high potassium content mineral (25). Though K 40 values dominated the radiological profile, both Ra 226 and Th 232 also displayed significant spatial variability. For both Ra 226 (1.050 Bq/L) and Th 232 (1.152 Bq/L), Basrah again recorded the highest values and indicated the likelihood of cumulative contamination. The occurrence of thorium and radium could be due to natural geological processes, use of phosphate

fertilizers, or nearness to industrial activities (26). Babylon, Al-Samawah, and Maysan provinces also showed elevated levels of these radionuclides, whereas northern and central provinces, such as Kirkuk, Erbil, and Diyala, always showed lower levels, indicating more stable background conditions (3). Some radiological indices were calculated to transform the raw concentration of activity into health-oriented measurements. The radium equivalent activity (Raeq), being one measure of the total impact of the three radionuclides, ranged between 2.64 and 8.17 Bq/L (13). The figures are well below the world safety level of 370 Bq/L and indicate that, as a cumulative, Iraqi milk is still within safe limits of consumption. However, more extreme Raeq values in Basrah, Babylon, and Al-Samawah reflect an accumulation pattern of radiological measure that cannot be ignored (27). The rate of absorption dose (D), which measures external exposure caused by gamma radiation, ranged from 1.256 to 4.163 nGy/h—once more far lower than the global average at 55 nGy/h. However, the highest values repeatedly measured in Basrah and surrounding provinces. Annual effective dose equivalent (AEDE), estimated to represent the internal dose obtained by individuals through ingestion of contaminated milk, trailed similar patterns (28). The AEDE varied from 1.540 μ Sv/y for Diyala up to 5.106 μ Sv/y for Basrah. A broader AEDE range intended to simulate more extensive patterns of consumption reached a maximum of 30.579 μ Sv/y (29). While all values fall within the limits of permissible exposure established by the UNSCEAR and ICRP, the intense concentration of high AEDE in certain provinces can result in cumulative exposure in the long term, especially for highly milk-consuming consumers (30). A more direct assessment of long-term LRM is the excess lifetime cancer risk (ELCR), ranging from 5.393×10^{-3} to 17.873×10^{-3} across provinces (31). Basrah again recorded the highest ELCR, with Babylon and Al-Samawah being the second-highest. While these data do not of themselves suggest a public health crisis, their relative ranking suggests that there is a need for continuous surveillance, particularly in the south of Iraq where environmental and industrial processes may be contributing to increased contamination (5). Further information regarding the levels of safety is provided by the hazard indices: the external hazard index (Hex), internal hazard index (Hin), and the representative gamma index (I_γ). The three indices were all less than unity, confirming that the radiological hazard due to the intake of milk is still within acceptable limits at the national level. Nonetheless, maximum values for all the indices were again found in Basrah, which supports the need for geographically targeted mitigation measures. On the other hand, Diyala, Al-Nasiriyah, and Kirkuk provinces had minimum hazard index values and therefore comparatively more stable environmental conditions along with smaller radiological burdens.

Radiological assessment of cow milk from 18 Iraqi provinces showed distinct regional variability in naturally occurring radionuclide levels and related radiological risk indicators. These observed differences in the concentrations of Ra-226, Th-232, and K-40 point to environmental heterogeneity and, at the same time, to possible anthropogenic inputs through the use of fertilizers and/or industrial activities (22). Among the radionuclides analyzed values, K-40 had the highest activity values because of its essential biological role and its natural abundance in the environment (23,24). The high value was in Basrah, with 79.04 Bq/L, followed by Babylon and Duhok. This may be related to soil rich in potassium and feed compositions and aquifer geochemistry. While K-40 had the highest concentrations, Ra-226 and Th-232 concentrations also varied highly among regions, showing that Basrah again had the highest levels: 1.050 and 1.152 Bq/L, respectively (25). It follows that there may be cumulative environmental inputs; the distribution of the radionuclides reflects either geological enrichment or contamination from phosphate fertilizers and industrial residues (26). Provinces such as Babylon, Al-Samawah, and Maysan also displayed elevated readings, while Kirkuk, Erbil, and Diyala showed lower baseline levels (3). Radiological indices further contextualized these findings in health terms. The radium equivalent activity (Raeq) ranged between 2.64 and 8.17 Bq/L, well below the 370 Bq/L global threshold, confirming general safety but revealing localized accumulation in Basrah, Babylon, and Al-Samawah (27). The absorbed dose rate (D) varied from 1.256 to 4.163 nGy/h, much lower than the world average of 55 nGy/h, though again higher in southern provinces. The annual effective dose equivalent (AEDE) ranged from 1.540 μ Sv/y in Diyala to 5.106 μ Sv/y in Basrah, with an extended simulation reaching 30.579 μ Sv/y (28,29). In spite of remaining below UNSCEAR and ICRP limits, repeated high AEDE values in some provinces highlight possible cumulative exposure risks for heavy milk consumers (30). These differences in the concentrations of Ra-226, Th-232, and K-40 indicate environmental heterogeneity and, at the same time, possible anthropogenic inputs through the use of fertilizers and/or industrial activities. Among the radionuclides analyzed, K-40 presented the highest values of activity due to its essential biological function and its natural abundance in the environment. The high value was in Basrah, with a value of 79.04 Bq/L, followed by Babylon and Duhok. This may be related to soil rich in potassium and feed compositions and aquifer geochemistry. While K-40 exhibited the highest concentrations, Ra-226 and Th-232 concentrations also showed high variations among regions, showing that Basrah again had the highest levels: 1.050 and 1.152 Bq/L, respectively. It follows that there might be cumulative environmental inputs; the distribution of the radionuclides reflects either a geological enrichment or contamination

from phosphate fertilizers and industrial residues. The hazard indices (Hex, Hin, I_y) were all below unity, confirming overall safety, yet their regional peaks in Basrah emphasize the importance of spatially focused mitigation and surveillance strategies.

Conclusion

Quantification of health risks and measurement of radionuclide concentrations from cow's milk collected from 18 provinces in Iraq. The average activity concentrations of Ra-226, Th-232, K-40 and their derived indices Raeq, AEDE, ELCR are safe as per international standards but some regional variations were observed. The southern provinces show a high value of radioactivity and hazard index. These include Basrah, Babylon, and Al-Samawah. Although the risk to public health is low, the issue is that the cumulative exposure especially to susceptible groups, namely, children and pregnant women must be examined. The study calls for regular milk testing; the establishment of radiological monitoring programs at the regional level; and advisories on dietary exposure in vulnerable areas. To ensure safety of dairy in Iraq and protect public health in the long term, ongoing monitoring along with mitigation and source-tracking research will be of utmost importance.

Acknowledgment

The author is grateful to the University of Mosul / College of Environmental Sciences for all the facilities to achieve this study.

Conflict of interest

There is no conflict of interest.

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النشاط الإشعاعي الطبيعي والمخاطر الإشعاعية في حليب البقر المستهلك في العراق

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الخلاصة

أثارت مشاكل الصحة العامة الحيوانية قلقًا متزايدًا بشأن السلامة الإشعاعية لمنتجات الألبان. تناولت هذه الدراسة، فحص مستويات النويدات المشعة - الراديوم-226 (Ra²²⁶)، والثوريوم-232 (Th²³²)، والبوتاسيوم-40 (K⁴⁰) في عينات حليب الأبقار التي جُمعت من ١٨ محافظة في العراق، بالإضافة إلى المخاطر الصحية الإشعاعية المقابلة. تم تحديد مستويات النشاط الإشعاعي بوحدات بيكريل/لتر، والتي حددت منها مؤشرات الخطر المهمة، مثل نشاط مكافئ الراديوم (Raeq)، ومعدل الجرعة الممتصة (D)، ومكافئ الجرعة الفعالة السنوية (AEDE)، وخطر الإصابة بالسرطان مدى الحياة (ELCR)، ومؤشرات الخطر (I_γ، H_{in}، H_{ex}). أظهرت النتائج تباينًا مكانيًا كبيرًا في تركيزات النويدات المشعة، حيث سجل K⁴⁰ أعلى قيم له في جميع العينات. في المقابل، سجلت البصرة أعلى القيم لكل من الراديوم (Ra²²⁶) والثوريوم (Th²³²) والبوتاسيوم (K⁴⁰)، كما سجلت أعلى قيمة لـ Raeq (8.17 Bq/L)، و D (٤.١٦ nGy/h)، و AEDE (5.11 μSv/y)، و ELCR (17.87 × 10⁻³).، حيث لوحظت جميع المعلمات الإشعاعية المحسوبة بأقل من معايير السلامة الدولية، على الرغم من أن البصرة وبابل والسماوة أظهرت قيمًا أعلى. بشكل عام، أظهرت الرسوم البيانية ومؤشرات المخاطر الإشعاعية والتحقق من ELCR فصلًا واضحًا للتعرض المتزايد في المناطق الجنوبية. على الرغم من هوامش الأمان الكافية، فإن المخاطر الإجمالية الموضحة بواسطة ELCR ومؤشرات المخاطر تُظهر الحاجة إلى المراقبة المستمرة، خاصة في المناطق الأكثر عرضة للخطر. تكمن أهمية هذا البحث في إلزام أصحاب المصانع والمزارع بمراقبة هذه المنتجات بشكل دوري والالتزام بالحدود المسموح بها وفقًا للمعايير الوطنية والدولية بما يضمن سلامة المنتج.