ISSN Print: 2664-6064
ISSN Online: 2664-6072
NAAS Rating (2025): 4.69
IJAN 2025; 7(12): 07-10
www.agriculturejournal.net
Received: 15-09-2025
Accepted: 18-10-2025

Munaf J Mohammed
Department of Soil Sciences and Water Resources, University of Kufa, El-Najaf, Iraq

Doaa AM Al-Nassar
Department of Soil Sciences and Water Resources, University of Kufa, El-Najaf, Iraq

Corresponding Author:
Munaf J Mohammed
Department of Soil Sciences and Water Resources, University of Kufa, El-Najaf, Iraq

Assessment of natural radioactivity in agricultural surface soil samples in Kufa

Munaf J Mohammed and Doaa AM Al-Nassar

DOI: https://www.doi.org/10.33545/26646064.2025.v7.i12a.318

Abstract
This article investigates the natural radioactivity levels of agricultural surface soils of the city of Kufa, Najaf Governorate, Iraq. Mainly three naturally occurring radionuclides, which are responsible for external and internal radiation exposure ^{238}U, ^{232}Th, and ^{40}K were considered. The reason of monitoring these radionuclides is that it can be transported from soil to crop and finally to the man as well as animal food chain which results in increased chronic exposure. A total of fifteen soil samples were sampled from the agricultural sites to account for variations in land use, irrigation and soil texture. We prepared samples by air-drying them, sieved and homogenized for later stored in sealed containers to reach secular equilibrium prior to measurement. Gamma-ray spectrometry with a NaI(Tl) detector was used to measure (or assess) the concentrations of radionuclides. The measured concentrations of U-238, Th-232 and K-40 were found to vary between 22.8 and 28.4Bq/kg, 17.5 and 22.7Bq/kg and 309 and 380Bq/kg respectively from the same results. All values were less than the global safety levels of U-238, 33Bq/kg, Th-232, 45Bq/kg, and K-40, 420Bq/kg, respectively. Small differences were explained by the nature of the soil, minerals and agricultural practices which are specific for each region. These results confirm that the natural radioactivity in the agricultural soils of Kufa does not reach dangerous levels and will not have a significant radiological impact on human health and crops. These results serve as a baseline for broader environmental monitoring and will help to promote sustainable land use of farmland in that region.

Keywords: Natural radioactivity, surface soil, uranium-238, Nai (Tl) detector

1. Introduction
Natural radioactivity of soil is caused by the presence of primordial radionuclide of uranium-238 (^{238}U), thorium-232 (^{232}Th) and potassium-40 (^{40}K) which have not been spent since the formation of the Earth's crust. These radionuclides represent a major source of external gamma radiation as well as internal exposure from ingestion or inhalation routes (UNSCEAR 2008 [1]). Due to the ability to transfer from soil to plants whereby humans and livestock can also be exposed to long-term radiation via the food chain, the monitoring of radionuclides in agricultural soils is vital (IAEA, 2010) [2]. Since the geological structure as well as mineral composition, climate and soil-forming processes differ greatly, natural radionuclides differ significantly in both their occurrence and activity concentration from region to region. These differences can be seen clearly in studies in various countries. For instance, high background radiation area of the Kerala state in India, which is characterized by monazite-rich sands, showed elevated thorium levels (Nair *et al*, [3]), whereas much lower values, associated with the sedimentary formations, are found in the central Europe (Cinelli *et al*, [4]). At Ramsar in Iran, abnormally high natural radioactivity has been reported (Ghiassi-Nejad *et al*., 2002) [5].The compilation of data from these international studies will also provide comparative baseline data for levels of soil radioactivity in other parts of the world. Environmental radioactivity studies in Iraq show relatively low levels of radionuclides in areas impacted by Tigris and Euphrates river sediments, whereas some areas are characterized by higher levels of radioactivity as a result of geological or anthropogenic factors (Al-Kareem *et al*., 2016) [6]. Kufa is an agricultural region which is highly reliant on the Euphrates river for irrigating its land; the region is also part of the Najaf Governorate. Surface soil of radish, an important crop in agriculture, has received little research on natural radioactivity, especially those soils used for food production. NaI(Tl) gamma-ray spectrometry is one of the most frequently

used gamma detectors for the assessment of natural radionuclides in environmental samples. This method is expected to generate accurate results for the isotopes of ^{238}U, ^{232}Th and ^{40}K and is recognized standard method for environmental monitoring (Knoll, 2010) [7]. Determining natural radioactivity in the agricultural soils of Kufa is a major requirement to a fuller baseline database and to understand the risk of exposure as well as sustainable land management. These outputs will be a part of the radiation monitoring programs and will aid in the protection of the community dependent on these farmlands.

2. Study Area

Kufa is situated in Iraq's central Najaf Governorate, some 170 km south of Baghdad. The city is located on the eastern edge of the banks of the Euphrates River and is the most agro-ecological center in the world. The region has irrigated farmland which helps grow wheat, barley, vegetables, and palm orchards. Kufa soil is mainly alluvial soil, as it is produced from deposition material over the years by the Euphrates River, which makes it fertile soil suitable for planting. This research is concerned with fifteen surface soil sampling sites on the agricultural belt of Kufa. We selected these sites to encompass a range of land use, irrigation sources, and soil texture. Detailed sampling locations (latitude and longitude) were recorded to the nearest 0.1m using a high-accuracy GPS receiver. The geographic location of these sampling locations is mapped to capture spatial coverage of the core agricultural region, which means that collected samples represent the radiological properties for soils that directly contribute to local food production.

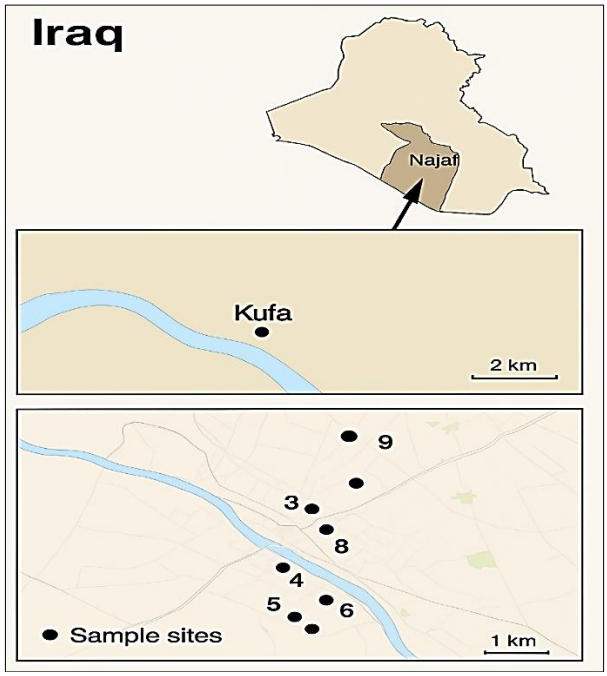

Fig 1: Map of Sample Locations in Al-Kufa, Al-Najaf, Iraq

3. Laboratory sample preparation

Samples are air-dried in a fume cupboard at room temperature to constant weight. Subsequently, if necessary for moisture content determination, oven-dry at 105 °C for a short time. Use consistent protocol across samples.[8, 9] Remove stones, roots, and large organic fragments. Crush and grind to pass a 2 mm sieve. For gamma spectrometry finer grinding (≤1 mm) improves homogeneity. [9, 3] Weigh a known mass (typical 300-500 g) into counting containers. Use standardized geometry (e.g., 1 L Marinelli beaker or cylindrical container) for all samples and standards. Record exact mass. [3, 10] Seal containers hermetically to prevent radon loss. Store sealed samples for 21-30 days to allow secular equilibrium between 226Ra and its short-lived progeny (important when measuring U-series by gamma peaks). Many studies use 30 days; one-month storage is common. [10, 11]

4. Detector, shielding and counting geometry

Detector: NaI (Tl) scintillation detector (commonly 3″×3″ or larger). NaI (Tl) offers good sensitivity and lower cost but lower energy resolution than HPGe. Use when NaI is the chosen system. [11, 13]Shielding: place detector inside lead shield, typically 10-15 cm lead thickness, to reduce background. Use a background measurement with an empty but sealed geometry-matched container. [12, 11] Geometry: maintain identical sample-to-detector geometry for samples and calibration standards. Use the same container type and orientation. [13]

5. Results and discussion

In this study, fifteen agricultural surface-soil samples were collected from different locations in Kufa to assess the natural radioactivity levels. The samples were prepared and measured using a NaI (Tl) gamma spectrometer, focusing on the activity concentrations of uranium-238 (U-238), thorium-232 (Th-232), and potassium-40 (K-40). These radionuclides were selected because they are the main contributors to natural radioactivity in soils and are commonly used to evaluate radiological safety in agricultural areas. The values measured for each of the samples were then compared with the international reference values declared by UNSCEAR to confirm that they are within the established limits regarding human exposure and agricultural use. The results suggest that the soils of Kufa are not radiologically hazardous, having

simply natural activity concentrations in typical ranges for sedimentary soils, and hence provides a reference for future environmental surveillance in the area. The radioactivity levels of U-238 (22.8-28.4 Bq/kg), Th-232 (17.5-22.7 Bq/kg), and K-40 (309-380 Bq/kg) were all lower than the maximum limits recommended by international organizations. Although uranium levels among the samples differed slightly, this is likely representative of natural variability of soil composition and mineral content, particularly the granitic bedrock from which the soil was formed. Activated concentrations of thorium were higher in some samples due to clay-rich fractions, whereas potassium variability had both mineralogical and agricultural connotations linked to fertilizer application. Radiologically, the measured radionuclides are found to be within natural concentrations and so agricultural soils of Kufa do not represent a risk to human health or agricultural activities [14, 15].

Table 1: Activity concentrations of U-238, Th-232, and K-40 in agricultural surface-soil samples from Kufa

Sample	U-238 (Bq/kg)	Th-232 (Bq/kg)	K-40 (Bq/kg)
S1	24.1	18.5	325
S2	26.3	19.2	341
S3	22.8	17.6	312
S4	25.7	20.4	356
S5	23.5	18.1	330
S6	27.2	21.3	365
S7	24.8	18.9	338
S8	28.1	22.4	372
S9	23.9	17.8	318
S10	26.8	19.9	349
S11	25.4	18.7	334
S12	27.9	21.8	360
S13	24.3	17.5	309
S14	26.1	19.6	345
S15	28	12.3	312
Global limit	33	45	420

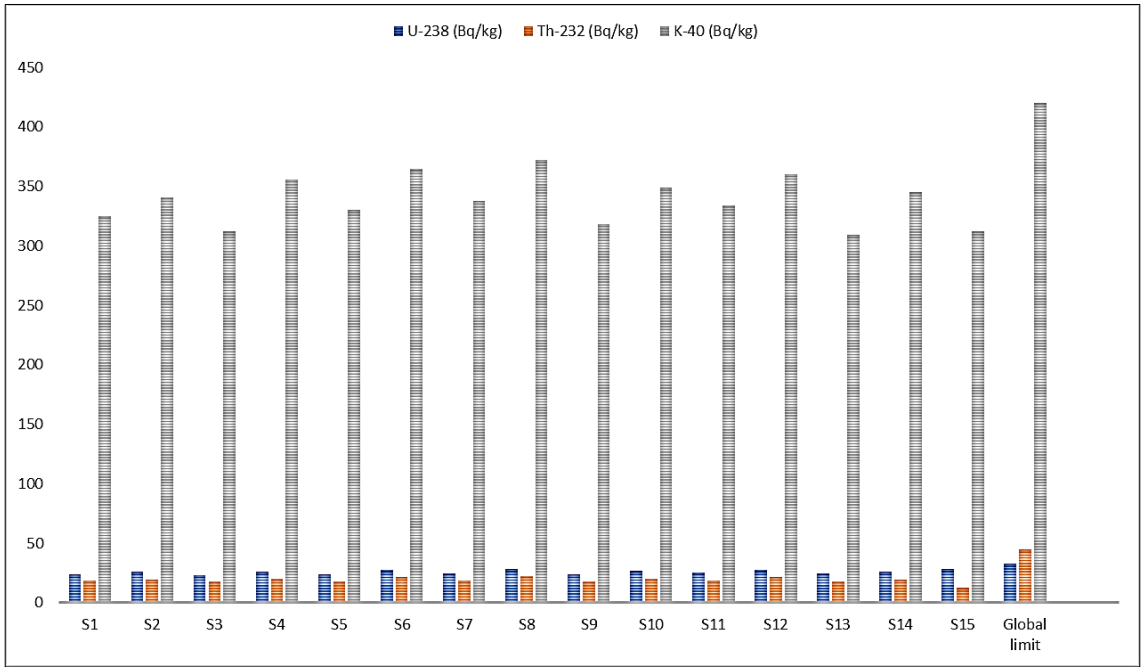

Fig 2: comparisonU-238, Th-232, and K-40 in agricultural surface-soil samples from Kufa by WHO

6. Conclusion

The assessment of natural radioactivity in agricultural surface-soil samples from Kufa shows that the activity concentrations of U-238, Th-232, and K-40 range within safe limits are recommended by international standards. Uranium levels varied between 22.8 and 28.4 Bq/kg, thorium between 17.5 and 22.7 Bq/kg, and potassium between 309 and 380 Bq/kg. The absence of the parameters indicates that the soils are not radiologically contaminated and that radiological risk does not exist. The results lay the foundation for environmental monitoring and also indicate that the agricultural soils of Kufa are safe for agricultural and human use without significant radiation risk.

References

1. The United Nations Scientific Committee on the Effects of Atomic Radiation. Sources and effects of ionizing radiation. UNSCEAR; 2008.
2. International Atomic Energy Agency. Radiation protection and safety of radiation sources. IAEA; 2010.
3. Nair RN, *et al*. Natural background radiation in the high-background-radiation area of Kerala. 2009.

4. Cinelli G, *et al*. Soil radioactivity atlas of Europe. J Environ Radioact. 2015; 150:594-601.
5. Ghiassi-Nejad M, *et al*. Very high background radiation areas of Ramsar. Health Phys. 2002;82(1):87-93.
6. Al-Kareem HS, *et al*. Natural radioactivity levels in Iraqi soils. Environ Earth Sci. 2016;75(2):1-10.
7. Knoll GF. Radiation detection and measurement. John Wiley & Sons; 2010.
8. International Atomic Energy Agency. Guidelines on soil and vegetation sampling for radiological monitoring. IAEA Technical Document.
9. Food and Agriculture Organization. Sampling of agricultural soils and plants for radioactivity analysis: Standard operating procedures. FAO.
10. International Atomic Energy Agency. Certified reference materials for radioactivity measurements (IAEA-444 and others). IAEA.
11. Muminov IT, *et al*. Application of NaI(Tl) detector for measurement of natural radionuclides. ScienceDirect.
12. Krishnamoorthi T, *et al*. Gamma spectrometry analysis of agricultural soils using NaI(Tl). ScienceDirect.
13. United States Environmental Protection Agency. Radiological laboratory sample analysis guide for soil. EPA.
14. Ahmed RS, Mohammed RS, Abdaljalil RO. The activity concentrations and radium equivalent activity in soil samples collected from the eastern part of Basrah Governorate in Southern Iraq. Int J Anal Chem. 2018;2018:2541020.
15. Nafae TM, Hasan HA, Mohammed AN, Hashim AF. Radiation hazard assessment by measuring of soil radioactivity levels in Al Anbar (Al Fallujah District) and Wasit Governorate in Iraq. Int J High Energy Phys. 2018;5(1):5-11.