

Assessment of Natural Background Gamma Radiation Levels in Different Areas of Najaf Governorate, Iraq

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Abstract

Natural background radiation is always there and is the main source of radiation exposure to the general population. The aim of this study was to determine the outdoor natural background gamma radiation level at various sites in Najaf Governorate, Iraq. Twenty-one sites, including various educational, residential, commercial and industrial areas were explored. At each site, measurements of gamma radiation were taken three separate times with a hand-held gamma radiation survey meter; geographical coordinates were obtained through a Garmin GPS device. The ambient dose rates measured at the different sites investigated were relatively small, with an average ambient dose rate between 0.07 and 0.13 $\mu\text{Sv h}^{-1}$. Kimo Factory had the highest average value while Baridi and Sayyid Jaafar Street had the lowest values. The total radiation readings that were made were found to be within the reference levels of the natural background radiation found in many countries and posed no radiological concern of the areas investigated. These results are used as baseline data which can be used for future environmental radiation monitoring programmes in the Najaf Governorate.

Keywords: Natural Background Radiation, Gamma Radiation, Environmental Monitoring, Ambient Dose Rate, Radiation Survey, GPS Mapping.

Introduction

The natural background radiation is derived from radionuclides found in terrestrial sources like rocks, soils, building materials and cosmic radiation that reaches the surface. Natural radiation exposure to humans depends on the geology, topography, soil properties and local environments. The monitoring of environmental gamma radiation is important to determine baseline level and to alert for any environmental change resulted from natural or anthropogenic sources that may pose a potential threat to public health (Almayahi, 2025). These surveys also help to support environmental protection programs and serve as reference data for future radiological assessments (Bari et al., 2015). Residential districts, education institutions, industrial facilities, and agricultural lands in Najaf Governorate have various geological properties (Hendry et al., 2021, Almayahi, 2025). Although it is of great importance, detailed field measurements in a number of districts are still limited. Thus, this study was undertaken to assess the spatial distribution of the natural background gamma radiation at selected sites in the Najaf Governorate (Hosoda et al., 2021). The aim of this work was to determine the ambient gamma dose rates at representative sites, and to provide a database for future environmental monitoring purposes for comparison with the measurements.

Materials and Methods

Study Area

Twenty-one sites were selected around Najaf Governorate for field measurements. The location selected were the various environmental conditions, such as university campus, residential area, industrial plant, commercial street and public space. The study was carried out in the city of Najaf located in the center of Iraq. Twenty-one sampling sites were chosen across a range of land-use categories, such as University campuses, residential, commercial, industrial and public road areas. The sites were selected to provide a suitable spatial coverage within the study area.

A Garmin GPS 72H receiver was used to determine geographical coordinates of all sampling sites. All the environmental radiation measurements were plotted in a Geographic Information System (GIS) environment, and the spatial distribution map was created to show the location of all measurements.

The twenty-one sampling points for the measurements of natural background gamma radiation in outdoor environment in Najaf Governorate, Iraq are shown in fig. 1. The survey sites were located in residential, educational, commercial and industrial areas such that they covered the study area.

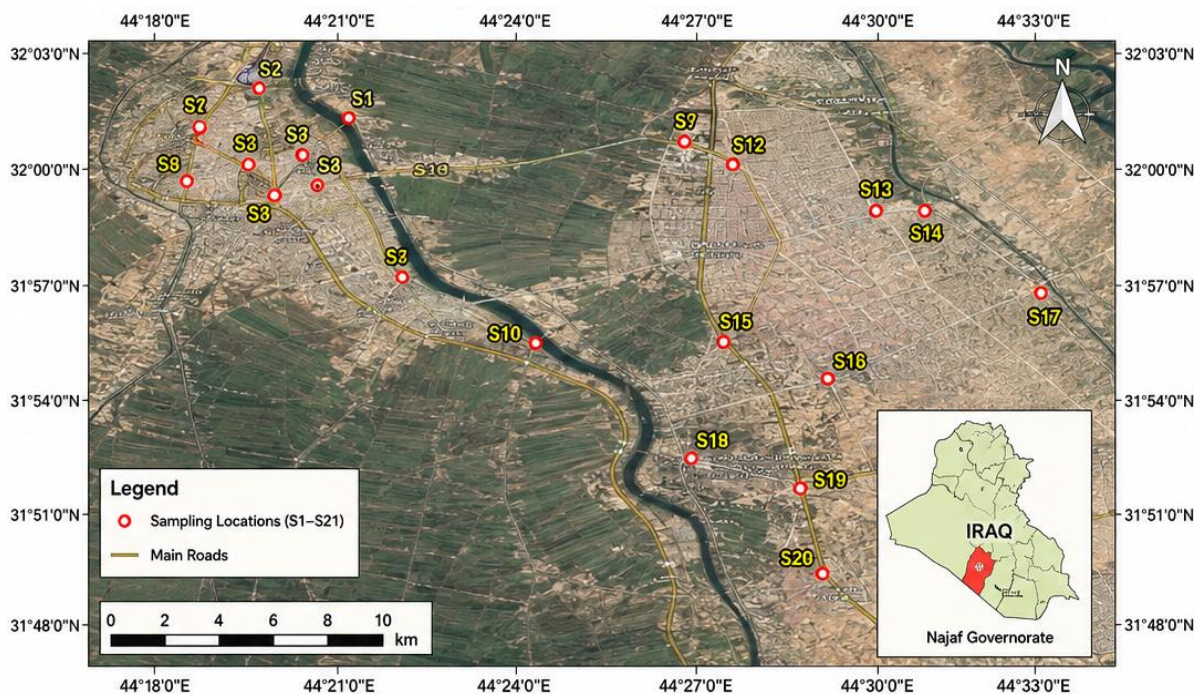


Fig. 1: Geographic Distribution of the 21 Outdoor Gamma Radiation Sampling Locations in Najaf Governorate, Iraq

Satellite coordinates were obtained for each site using a Garmin GPS 72H GPS Receivers and then plotted on a satellite image with Geographic Information System (GIS) software (Fig. 2a). The spatial distribution of sampling points allowed the assessment of the distribution of ambient gamma dose rate level in various parts of the governorate. The spatial distribution of the sampling points enabled the assessment of variations in ambient gamma dose rate level in various parts of the governorate.



Fig. 2a: Garmin GPS 72H Receiver



Fig. 2b: Portable Gamma Radiation Survey Meter

Radiation Measurements

The portable gamma radiation survey meter (Fig. 2b) was used to measure the ambient radiation. Three independent measurements (N1, N2 and N3) were taken at each site under similar environmental conditions. The average dose rate (arithmetic mean) was determined and used as the representative dose rate of the location. The detector was maintained at a distance of about one meter from the ground level so as to limit the effects of the local surface irregularities and therefore to have a uniform situation for the measurement.

Geographic Coordinates

All sampling site's locations were determined by a Garmin GPS 72H receiver. Coordinates of latitude and longitude were recorded for mapping and analysis of space.

Data Analysis

All the measurements were tabulated in MS EXCEL. Means were computed for each sampling site. The average dose rates at the various locations were compared to determine the spatial variation of ambient dose rate (Fig. 3).

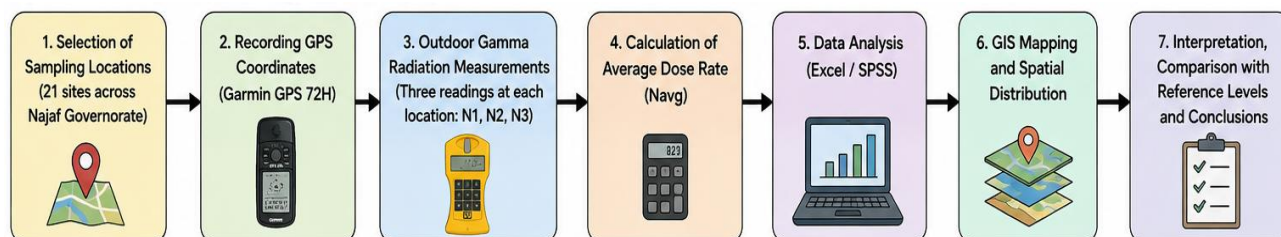


Fig. 3: Flowchart of the Methodology Used in this Study

Results

The twenty-one locations were successfully surveyed in the Governorate of Najaf. Three measurements were taken for each site. The average ambient dose rates measured at the various sites ranged from about 0.07 to 0.13 $\mu\text{Sv h}^{-1}$, indicating relatively uniform natural background radiation in the study area. The highest was at Kimo Factory with 0.13 $\mu\text{Sv h}^{-1}$ while the lowest were recorded at Baridi (0.07 $\mu\text{Sv h}^{-1}$) and Sayyid Jaafar Street (0.07 $\mu\text{Sv h}^{-1}$). The differences between the repeated measurements made at each location were small, suggesting that the measurements had good measurement stability and acceptable repeatability of the field survey. GPS data taken at each sample location can be used for future GIS mapping and for long-term environmental monitoring.

In terms of space, the spatial distribution of the studied sites for the study area in Najaf Governorate is presented in fig. 4. The locations of the samples were in the northern, central, and southern portions of the study area, so that an assessment of possible spatial variations in outdoor gamma radiation levels could be conducted. The spatial distribution of the measurement points is relatively uniform due to which spatial bias is reduced and reliability of the environmental radiation survey is enhanced. Ambient gamma dose rates measured were in the range of 0.07 to 0.13 $\mu\text{Sv h}^{-1}$. The investigated locations showed minor spatial variations with most having values in the range of 0.08 - 0.11 $\mu\text{Sv h}^{-1}$ of natural background radiation.

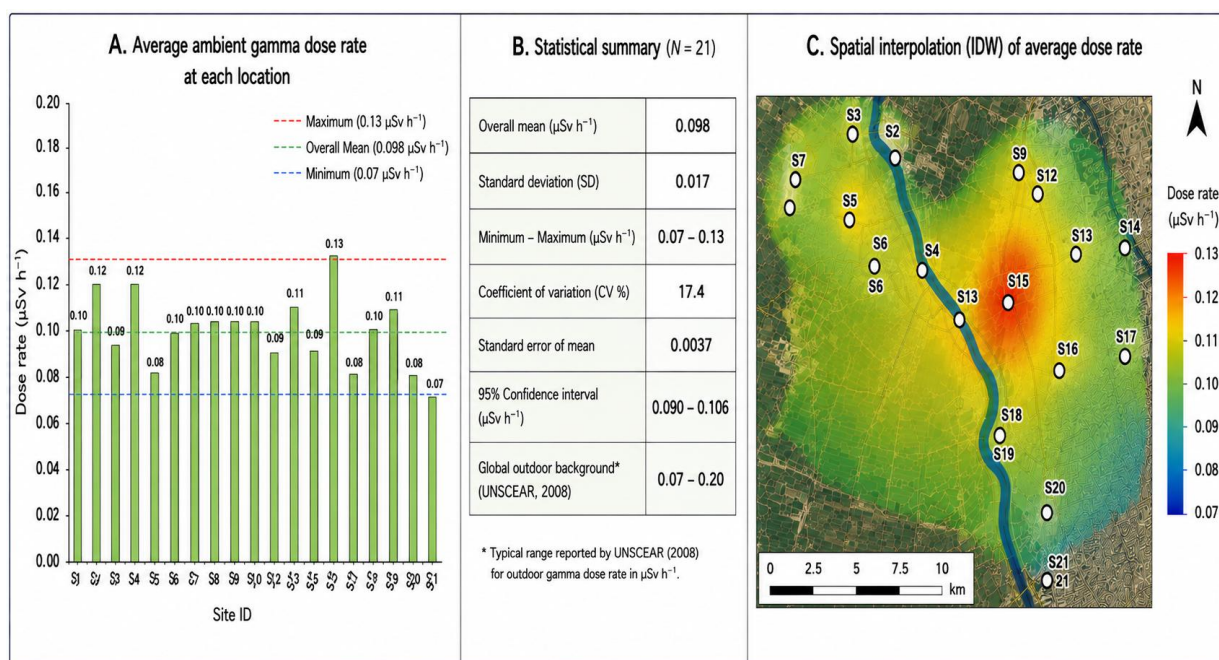


Fig. 4: The Spatial Distribution of the Investigated Sites (A) Gamma Dose Rate, (B) Statistical Summary, (C) Special Interpolation

Discussion

The gamma dose rates measured in the Governorate of Najaf pointed out that the natural background radiation of the area is relatively homogeneous. Local variations can be explained by local geological features, mineral content of the soil, building materials and the concentrations of natural radionuclides. The highest readings were in the range of outdoor natural background radiation levels generally reported for the rest of the world, and do not show any abnormal environmental contamination. Repeated measurements show consistency, indicating the reliability of the field survey methodology. The GPS location coordinates recorded also serve as a useful baseline data for future spatial radiation mapping and environmental monitoring campaigns. The results of the investigations indicate that the areas are in general radiologically safe in respect of external gamma exposure from natural sources.

The ambient gamma dose rates measured outdoors in the present study (0.07–0.13 $\mu\text{Sv h}^{-1}$) show a relatively uniform spatial distribution of natural background radiation in the investigated places in Najaf Governorate. Spatial variation was small, indicating that the land use and geology are generally similar at the sampling sites.

The current results agree with the ones obtained in previous investigations of environmental radiation in Iraq. Almayahi et al., (2018) found that the gamma radiation dose rate at outdoor environments in the provinces of Najaf and Dhi Qar was all within the internationally acceptable background radiation limits and concluded that there was no significant radiological hazard to the people. Similarly, further investigation in Najaf showed that the ambient dose rates measured were in the normal environmental background range, and could be used as environmental reference values for future monitoring.

The results are also similar to recent international studies. A long-term environmental radiation monitoring program has been carried out in Kolkata, India, and the average absorbed gamma dose rate in outdoor environment was found to be $107 \pm 12 \text{ nGy h}^{-1}$, which is consistent with the natural background radiation for 14 years. The authors emphasized the importance of continuous monitoring that will give good baseline information for environmental radiation assessment (Mitra et al., 2024b).

Likewise, a national radiation survey that measured gamma radiation in urban areas in Italy showed that a systematic outdoor gamma survey can be an effective method to estimate population exposures and provide representative background data in urban areas. The study emphasized the need of a robust national radiological database that is enhanced with a systematic survey protocol and comprehensive field measurements (Carpentieri et al., 2024).

Long-term monitoring in Bengaluru, India, based on 41 monitoring sites in 10 years, also revealed relatively stable outdoor gamma dose rates, despite geological differences within the area. The study also found that continuous environmental monitoring serves as a crucial tool for identifying potential changes that may occur with future environmental change, both natural and anthropogenic (Mitra et al., 2024b).

Moreover, GIS integration in the field radiation measurements has recently been stressed as a way of improving visualization of the spatial variability and environmental decision making. GIS mapping helps in the detection of local anomalies and enhances environmental monitoring and creates reference maps for future radiological surveys (Suman et al., 2025).

Generally, the measured dose rates on the present investigation are in the range reported in the literature and do not show any unexpected radiological risk. These measurements are good baseline for environmental monitoring programs in Najaf Governorate in the future.

Conclusion

This study provided baseline data for the natural background gamma radiation of the area in outdoor environment at 21 points in Najaf Governorate. The ambient dose rates measured ranged from about 0.07 to 0.13 $\mu\text{Sv h}^{-1}$, and there was only a small variation in ambient dose rates among sampling locations. The environmental gamma radiation in all the areas investigated was within the normal environmental background limits as no unusually high radiation level was found at any location. The resultant database can be used as a useful data source for future environmental radiation monitoring, radiological impact assessment and GIS-based radiation mapping for Najaf Governorate.

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