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SPATIAL MAPPING AND RADIOLOGICAL RISK ASSESSMENT OF OUTDOOR GAMMA DOSE RATES IN GAZIANTEP PROVINCE, TÜRKİYE

ABSTRACT

Natural terrestrial gamma radiation continuously drives environmental exposure to ionizing radiation and shows substantial spatial heterogeneity shaped by local conditions. In this study, outdoor ambient gamma radiation across Gaziantep Province, Türkiye, was systematically mapped using field measurements from 212 georeferenced locations. Exposure levels were recorded 1 m above the ground using a calibrated Eberline ESP-2 ratemeter paired with an SPA-6 plastic scintillation detector, averaging three consecutive 60-s readings to determine site-specific values. The absorbed dose rate in air (ADRA) spanned 20.9 to 159.2 nGy h^{-1}, yielding a provincial mean of 55 nGy h^{-1}. The corresponding annual effective dose equivalent (AEDE) was determined as 67.5 μSv y^{-1}, while lifetime cancer risk (LCR) values were calculated as 0.027, 0.030, and 0.034 under the ICRP 103, BEIR VII, and ICRP 60 frameworks, respectively. GIS-driven inverse distance weighting interpolation revealed marked spatial divergence, capturing localized hotspots of elevated dose rates. Overall radiation levels agreed well with reported values from adjacent regions in Türkiye, with the provincial mean remaining lower than the UNSCEAR baseline. This spatially resolved dataset serves as a robust baseline for regional radiation monitoring and provides a foundation to assess underlying geological and geographic drivers of terrestrial gamma radiation across southeastern Türkiye.

Keywords: Outdoor Gamma Radiation, Absorbed Dose Rate, Environmental Radioactivity, Radiological Risk Assessment, Spatial Heterogeneity

1. INTRODUCTION

Ionizing radiation acts as a ubiquitous environmental stressor capable of eliciting both direct and indirect biological responses in human organisms. Population exposure stems from two distinct contributors: natural background radiation and anthropogenic inputs. The primary components of natural exposure comprise galactic cosmic radiation and terrestrial radioactivity associated with naturally occurring radionuclides dispersed in geological matrices [1]. Cosmogenic radionuclides are continuously generated through spallation interactions between high-energy cosmic particles and atmospheric atomic nuclei; conversely, terrestrial background radioactivity originates from primordial nucleosynthesis events predating terrestrial formation. The terrestrial radiation flux is dominated by primordial radionuclides—specifically ^{238}U, ^{232}Th, and ^{40}K that have persisted since planetary accretion. Geochemical weathering and mechanical erosion facilitate the mobilization of these radioisotopes from the lithosphere, promoting

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their transport across ecological compartments via hydraulic, aeolian, and gravitational vectors [2]. Globally, natural background sources remain the major contributor, accounting for roughly 80% of the collective effective dose delivered to the human population [3]. Evaluating terrestrial gamma radiation exposure is essential as it forms the main component of external population doses [4], exhibiting marked spatial heterogeneity shaped by local topographic and lithological characteristics [5]. Variations in the mineralogical and geochemical composition of soil and rock matrices directly govern the spatial distribution and activity concentrations of terrestrial radionuclides, thereby modulating the outdoor gamma exposure rate at the standard reference height of 1 m above ground level and determining the resulting absorbed dose rate in air [6]. Ionizing radiation—originating from either naturally occurring or anthropogenic sources—possesses sufficient quantum energy to induce direct atomic ionizations, alter biomolecular structures, and precipitate cellular injury within biological tissues. Although low-dose radiation stress is routinely mitigated by intrinsic metabolic repair pathways, protracted or elevated exposures can trigger double-strand DNA breaks, somatic genetic mutations, carcinogenesis, radiation-induced cataracts, and other chronic pathologies [7-11]. In light of these biological risks, the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) strongly advocates for the systematic and precise assessment of biological exposure levels to provide a scientific foundation for public health risk management [1]. Field-based radiological surveys conducted across Türkiye have progressively expanded the understanding of regional variations in ambient gamma radiation, terrestrial radionuclide distributions, and their associations with geological, pedological, and environmental characteristics [12–32]. Nevertheless, Gaziantep, a strategically important and densely populated region, remains comparatively underrepresented in the existing radiological literature. This spatial deficiency hampers the development of a coherent regional radiation baseline and limits the robustness of dose characterization and population-level radiological risk assessments.

2. RESEARCH SIGNIFICANCE

Characterizing the spatial variability of terrestrial gamma radiation is essential for establishing reliable environmental radiation reference levels and improving the interpretation of natural background exposure. In this context, the present study provides a spatially extensive assessment of outdoor gamma radiation across Gaziantep Province, based on measurements obtained from 212 georeferenced locations. The principal significance of the study lies in the integration of field-based gamma-radiation measurements with dose assessment, lifetime cancer-risk estimation, and GIS-based spatial analysis. Rather than relying solely on a provincial average, the study resolves local variations in the terrestrial radiation field and identifies areas exhibiting relatively elevated dose rates. This spatial perspective provides a more informative representation of environmental radiation conditions across a heterogeneous geographical region. The resulting dataset establishes a regional reference for outdoor gamma radiation in Gaziantep and enables comparison with measurements reported from other parts of Türkiye. The combined assessment of absorbed dose rate, annual effective dose, and lifetime cancer risk further places the measured radiation field within a radiological protection framework. Importantly, the spatially resolved measurements provide a foundation for subsequent investigations of the relationship between terrestrial gamma radiation and geological, geographical, and environmental characteristics. The study therefore extends beyond a conventional radiation survey by providing a structured baseline that can support long-term environmental radiation surveillance and future regional radiological assessments in southeastern Türkiye.

Highlights

- Spatial variability of terrestrial gamma radiation was resolved across Gaziantep.
- Measurements at 212 sites captured local-scale radiation differences.
- Elevated dose rates were concentrated within specific geographical sectors.
- Radiological risk was evaluated through three complementary risk approaches.
- The study provides a spatial reference for regional radiation surveillance.

3. MATERIALS AND METHODS

3.1. Study Area and Sampling Design

Gaziantep Province is situated at the transition between the Southeastern Anatolia and Mediterranean regions of Türkiye and encompasses an area of approximately 6,887 km². Geographically, the province extends from 36° 28′ to 38° 01′ E longitude and from 36° 38′ to 37° 32′ N latitude. The geographical extent and administrative boundaries of the study area are presented in Figure 1, which also indicates the locations considered in the outdoor gamma radiation survey.

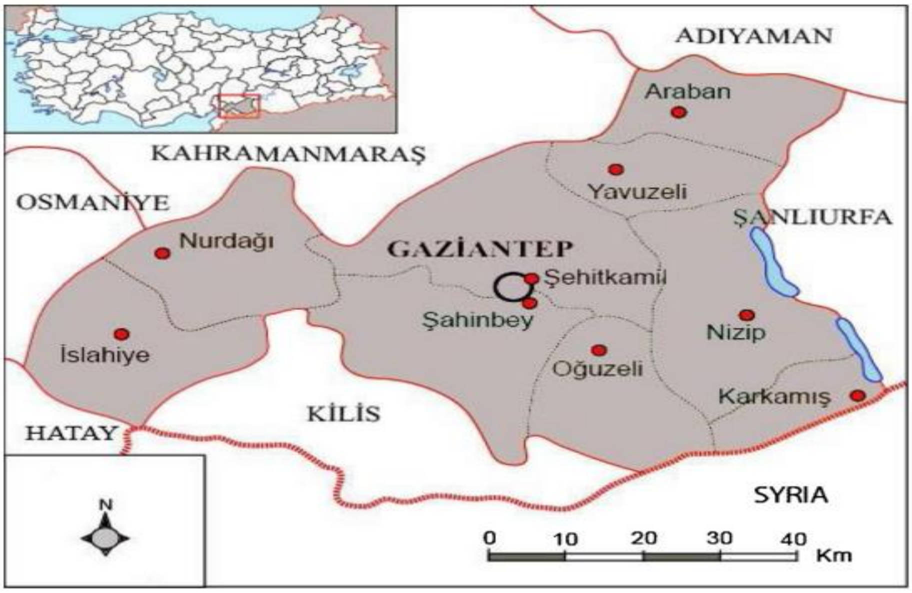

Figure 1. Research Region of Gaziantep [33]

The topography of Gaziantep is characterized by considerable elevation variability, with approximately 52% of the provincial territory consisting of mountainous areas and approximately 27% comprising plains. The provincial center is located at an elevation of approximately 850 m above sea level, whereas the maximum elevation reaches 2493 m [34,35] From a geological perspective, the region contains both allochthonous and autochthonous geological units. The allochthonous assemblages include the Karadut and Koçali complexes together with associated ophiolitic structures that tectonically overlie these units. The autochthonous formations extend stratigraphically from the Maastrichtian to the Lower Miocene and constitute a sequence with an approximate thickness of 1800 m. A total of 212 outdoor measurement locations were distributed across the administrative districts of Gaziantep Province. The sampling framework was established to provide spatial coverage of the province while considering geographical distribution, population, elevation, and catchment area. The geographical coordinates of the sampling sites were obtained using handheld global positioning system (GPS) devices.

Table 1. Geographic and demographic characteristics and distribution of outdoor gamma-radiation measurement stations across the districts of Gaziantep Province

District	Latitude (N)	Longitude (E)	Population	Catchment area (km^2)	Altitude (m)	Number of Stations
Araban	37.4254	37.6896	32292	592	566	15
Yavuzeli	37.3183	37.5668	21758	468	565	20
Nizip	37.0099	37.7969	140779	944	510	34
Karkamis	36.8358	37.9953	9558	341	365	16
Oguzeli	36.9653	37.5107	30943	689	750	20
Sahinbey	37.0633	37.3814	902424	960	900	22
Sehitkamil	37.0686	37.3730	760849	1250	850	27
Islahiye	37.0253	36.6311	57714	865	530	29
Nurdagi	37.1760	36.7406	39228	697	570	29

The district-level sampling distribution, population characteristics, elevation, catchment area, and geographical coordinates provide the spatial context required for interpreting variations in outdoor gamma radiation throughout the province. For each measurement site, the geographical position was determined by GPS, while the altitude information was used to characterize the relationship between radiation measurements and local topographic conditions.

3.2. Outdoor Gamma Radiation Measurements

Outdoor gamma radiation was quantified in situ using an Eberline ESP-2 portable ratemeter coupled with an SPA-6 plastic scintillation detector. To minimize measurement variability arising from detector geometry, the detector was maintained at a fixed height of 1 m above the ground at all sampling locations. At each site, the instrument was operated under identical acquisition conditions and three successive counting periods of 60 s were recorded. The three readings were subsequently averaged arithmetically to obtain a representative gamma exposure dose rate for each sampling location. The resulting measurements were expressed in μR h^{-1} and used as the primary field data for subsequent dose-rate conversion and radiological assessment.

Table 2. District-level variation in gamma exposure dose rates (GEDR) and absorbed dose rates in air (ADRA) across Gaziantep Province

	GEDR (μR h^{-1})			ADRA (nGy h^{-1})		
District	Minimum	Maximum	Mean	Minimum	Maximum	Mean
Araban	4.07	9.99	6.11	35.4	86.9	53.2
Yavuzeli	3.37	7.28	5.66	29.3	63.3	49.2
Nizip	4.31	7.92	6.23	37.5	68.9	54.2
Karkamis	4.32	8.20	6.44	37.6	71.3	56.0
Oguzeli	3.87	9.07	6.26	33.7	78.9	54.5
Sahinbey	2.92	6.54	4.91	25.4	56.9	42.7
Sehitkamil	3.51	9.85	5.83	30.5	85.7	50.7
Islahiye	2.57	18.30	7.49	22.4	159.2	65.1
Nurdagi	2.40	14.33	6.62	20.9	124.7	57.6
Region	2.40	18.30	6.32	20.9	159.2	55.0

The Eberline ESP-2 is a portable radiation survey instrument based on an Intel 80C31 microcontroller and equipped with a 2×16 character alphanumeric liquid crystal display. Gamma-induced detector pulses are converted into count rate information that reflects the intensity of the ambient gamma-radiation field. The instrument incorporates multistage linear signal amplification and an adjustable threshold discrimination system to enhance signal quality by suppressing electronic noise and reducing the influence of extraneous signals. Independent high and low voltage power supplies support stable operation during field measurements[36]. Calibration was carried out biennially at the Turkish Accreditation Agency accredited Secondary Standard Dosimetry Laboratory to maintain measurement traceability and verify the instrument's long-term performance. The calibration established traceability to relevant national and international measurement standards. Considering variations in field conditions and detector response, the overall measurement uncertainty was estimated to be within ±5–10 %. A photograph of the measurement system is provided in Figure 2.

Figure 2. Eberline ESP-2 portable ratemeter coupled with an SPA-6 plastic scintillation detector for outdoor gamma-radiation measurements

3.3. Conversion of Gamma Exposure Dose Rate to Absorbed Dose Rate

Following the acquisition of three consecutive measurements at each sampling location, the arithmetic mean gamma exposure dose rate was calculated and expressed in μR h^{-1}. The resulting gamma exposure dose rates were subsequently converted into absorbed dose rates in air using the conversion coefficient of 8.7 nGy μR^{-1}. The annual effective dose equivalent (AEDE) was subsequently determined from the absorbed dose rate in air using the following relationship [1].

$$\mathrm{AEDE} = \mathrm{ADRA} * \mathrm{DCF} * \mathrm{OF} * \mathrm{T} \quad (1)$$

where ADRA represents the absorbed dose rate in air (nGy h^{-1}), DCF is the adult dose conversion factor (0.7 Sv Gy^{-1}), OF denotes the outdoor occupancy factor (0.2), and T corresponds to the total exposure time in one year (8.760 h y^{-1}).

3.4. Lifetime Cancer Risk Assessment

The potential lifetime radiological health risk associated with outdoor gamma radiation exposure was assessed by estimating the lifetime cancer risk (LCR) for the local population. The calculation was performed using the annual effective dose equivalent and the following expression [37].

$$\mathrm{LCR} = \mathrm{AEDE} * \mathrm{DL} * \mathrm{RF} \quad (2)$$

where AEDE is the annual effective dose equivalent, DL denotes the assumed average human lifespan, taken as 70 years, and RF represents the fatal cancer risk coefficient (Sv^{-1}).To provide a comparative assessment under different radiological protection frameworks, risk coefficients recommended by ICRP Publication 103, BEIR VII, and ICRP Publication 60 were applied [38,39] The corresponding fatal cancer risk coefficients adopted in the present analysis were 0.057, 0.064, and 0.072, respectively.

3.5. Spatial Analysis and Mapping

The geographical coordinates of all measurement locations were recorded using handheld GPS devices. The spatial distribution of outdoor gamma radiation throughout Gaziantep Province was subsequently evaluated using the Inverse Distance Weighted (IDW) interpolation technique implemented in ArcGIS version 10.2. The interpolation procedure was used to generate continuous spatial representations of the measured gamma radiation levels and to visualize the geographical variability of outdoor gamma exposure across the province. The spatial mapping and visualization of the measured radiation data were performed using ArcGIS ArcMap version 10.2. The resulting maps were used to characterize the spatial distribution of absorbed dose rates in air across the administrative districts of Gaziantep.

3.6. Measurement Conditions and Uncertainty Considerations

All absorbed dose and radiological risk calculations were performed under the assumption of dry soil conditions. This consideration is particularly relevant because the measurements were carried out during the summer period. Accordingly, the reported outdoor gamma dose-rate values represent environmental conditions associated with relatively dry soil in the study region. The use of a standardized detector height of 1 m, three consecutive 60 s measurements at each location, and arithmetic averaging was adopted to improve measurement consistency and reduce the influence of short-term statistical fluctuations. The instrumental uncertainty was maintained within the range of ±5–10%, depending on environmental conditions and detector response. The methodology therefore combined standardized in situ gamma radiation measurements, conversion of exposure dose rates to absorbed dose rates in air, annual effective dose estimation, lifetime cancer risk assessment using three established risk models, and GIS-based spatial interpolation. This integrated approach enabled the outdoor radiological characteristics of Gaziantep Province to be evaluated consistently across the 212 surveyed locations.

4. RESULTS AND DISCUSSION

4.1. Spatial Distribution of Outdoor Gamma Radiation

A total of 212 outdoor measurement locations distributed throughout Gaziantep Province were investigated to characterize the spatial variability of terrestrial gamma radiation and to quantify the corresponding absorbed dose rate in air (ADRA). At each sampling location, measurements were obtained at a standardized height of 1 m above the ground surface, with three consecutive 60 s readings collected to minimize short-term statistical fluctuations. The arithmetic mean of the three measurements was adopted as the representative value for each station.

Across the investigated region, the gamma exposure dose rate (GEDR) varied from 2.40 to 18.30 μR h^{-1}, whereas the corresponding ADRA values ranged from 20.9 to 159.2 nGy h^{-1}, with a provincial mean of 55 nGy h^{-1}. The broad range observed among individual stations indicates appreciable spatial heterogeneity in outdoor gamma radiation across Gaziantep.

Nevertheless, the overall mean remained below the worldwide reference value of approximately 60 nGy h^{-1} reported by UNSCEAR [1]. The district-level results demonstrate that the magnitude of outdoor gamma radiation was not spatially uniform. The lowest mean ADRA was recorded in Şahinbey (42.7 nGy h^{-1}), whereas the highest district mean occurred in İslahiye (65.1 nGy h^{-1}). The remaining districts exhibited intermediate mean values, including 49.2 nGy h^{-1} in Yavuzeli, 50.7 nGy h^{-1} in Şehitkamil, 53.2 nGy h^{-1} in Araban, 54.2 nGy h^{-1} in Nizip, 54.5 nGy h^{-1} in Oğuzeli, 56.0 nGy h^{-1} in Karkamış, and 57.6 nGy h^{-1} in Nurdağı. The most pronounced local maximum was observed in İslahiye, where the ADRA reached 159.2 nGy h^{-1}, followed by Nurdağı with a maximum value of 124.7 nGy h^{-1}. These localized elevations contrast with the relatively low mean values observed throughout most of the province and indicate that local geological and environmental characteristics may exert an important influence on terrestrial gamma radiation. The spatial pattern of ADRA across the province is illustrated in Figure 3. The isodose map provides a spatial representation of the measured radiation field and highlights areas where relatively elevated or reduced gamma dose rates occur.

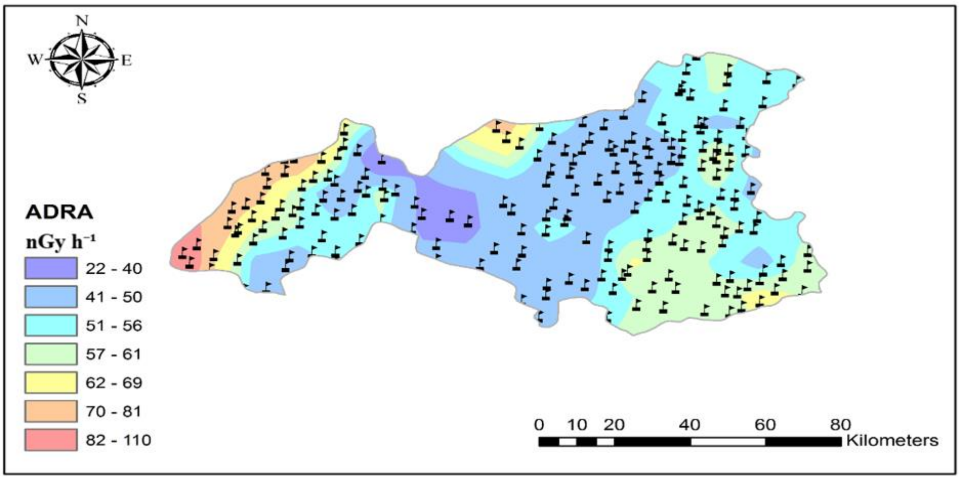

Figure 3. Spatial distribution of Absorbed Dose Rate in Air (ADRA) across Gaziantep Province

The observed spatial variability is consistent with the established understanding that terrestrial gamma radiation is strongly controlled by geological and environmental characteristics. The distribution and concentration of naturally occurring radionuclides in the near-surface environment are influenced by lithology, mineralogical composition, soil properties, topography, and geomorphological processes. Accordingly, differences in the geological substrate can produce measurable variations in ambient gamma radiation levels.

4.2. Annual Effective Dose Equivalent and Lifetime Cancer Risk

The second stage of the analysis involved the estimation of the annual effective dose equivalent (AEDE) and lifetime cancer risk (LCR) associated with outdoor gamma radiation exposure. AEDE values were derived from the district specific mean absorbed dose rates using Equation (1), while LCR was estimated using Equation (2) under the three radiological risk frameworks represented by ICRP 103, BEIR VII, and ICRP 60. The calculated AEDE values showed moderate spatial variation among the districts. The lowest value was obtained for Şahinbey (52.4 μSv y^{-1}), while the highest value was estimated for İslahiye (79.8 μSv y^{-1}). The AEDE values for Araban, Yavuzeli, Nizip, Karkamış, Oğuzeli, Şehitkamil, and Nurdağı were 65.2, 60.3, 66.5, 68.7, 66.8, 62.2, and

70.6 µSv y^{-1}, respectively. The corresponding provincial value was 67.5 µSv y^{-1}.Importantly, the estimated provincial AEDE remained substantially below the 1 mSv y^{-1} public exposure reference level associated with ICRP Publication 60[40]. This result indicates that the contribution of measured outdoor gamma radiation to population exposure in Gaziantep is relatively low when evaluated against the applicable radiological protection benchmark. The estimated LCR values followed the same general spatial pattern as the AEDE results. For the province as a whole, the mean lifetime cancer risk was 0.027 according to ICRP 103, 0.030 according to BEIR VII, and 0.034 according to ICRP 60. At the district scale, the lowest values were consistently obtained for Şahinbey, whereas the highest values occurred in İslahiye. The latter exhibited LCR values of 0.032, 0.036, and 0.040 according to ICRP 103, BEIR VII, and ICRP 60, respectively.

Table 3. District-level annual effective dose equivalent (AEDE) and lifetime cancer risk (LCR) estimated using ICRP 103, BEIR VII, and ICRP 60 risk coefficients for Gaziantep Province

		Lifetime cancer risk (probability)		
District	AEDE (µSv y^{-1})	ICRP 103	BEIR VII	ICRP 60
Araban	65.2	0.026	0.029	0.033
Yavuzeli	60.3	0.024	0.027	0.030
Nizip	66.5	0.027	0.030	0.034
Karkamis	68.7	0.027	0.031	0.035
Oguzeli	66.8	0.027	0.030	0.034
Sahinbey	52.4	0.021	0.023	0.026
Sehitkamil	62.2	0.025	0.028	0.031
Islahiye	79.8	0.032	0.036	0.040
Nurdagi	70.6	0.028	0.032	0.036
Region	67.5	0.027	0.030	0.034

4.3. Comparison with Other Regions in Türkiye and Global Reference Values

To assess the radiological characteristics of Gaziantep in a broader regional context, the measured absorbed dose rate in air (ADRA) and estimated annual effective dose equivalent (AEDE) were compared with published data from selected regions of Türkiye and the global reference values reported by UNSCEAR[1]. The comparative results are summarized in Table 4.

Table 4. Regional comparison of Absorbed Dose Rate in Air (ADRA) and annual effective dose equivalent (AEDE) for Gaziantep, selected regions of Türkiye, and the global reference values

Location	ADRA (nGy h^{-1})	AEDE (µSv y^{-1})
İstanbul [12]	65	79.7
Kastamonu [13]	54.81	67.21
Şanlıurfa [14]	60.9	74.7
Kırklareli [15]	118	144.7
Tekirdağ [16]	43.85	53.77
Yalova [17]	84	103
Trabzon [18]	59	72.4
Çankırı [19]	69.6	87.7
Balıkesir [20]	127	155.8
Yalova [22]	48.1	59
Konya [23]	-	132.9
Bolu [24]	22.2	27.23
Çorum [25]	44.96	55.14
Nevşehir [26]	178.69	219.07
Tavşanlı, Kütahya [27]	86.96	106.64
Adıyaman [28]	144.3	177
Adana [21]	71.2	87.3
Osmaniye[29]	40.5	50.1
Gaziantep [Present Study]	55	67.5
World average [1]	60	70

The mean ADRA obtained for Gaziantep was 55.0 nGy h^{-1}, which falls within the range reported for the selected regions of Türkiye. This value is comparable to those reported for Kastamonu (54.81 nGy h^{-1}), Şanlıurfa (60.9 nGy h^{-1}), and Çorum (44.96 nGy h^{-1}) [13, 14 and 25]. In contrast, considerably higher ADRA values have been reported for Nevşehir (178.69 nGy h^{-1}), Adıyaman (144.3 nGy h^{-1}), Balıkesir (127.0 nGy h^{-1}), and Kırklareli (118.0 nGy h^{-1})[15, 20, 26 and 28], whereas lower values were reported for Bolu (22.2 nGy h^{-1}) and Tekirdağ (43.85 nGy h^{-1})[16 and 24]. These variations indicate substantial spatial heterogeneity in terrestrial gamma-radiation levels across the investigated regions of Türkiye and may be associated with differences in local geological and environmental characteristics. The AEDE estimated for Gaziantep was 67.5 µSv y^{-1}, which is close to the global reference value of 70 µSv y^{-1} reported by UNSCEAR [1]. The Gaziantep value is lower than those reported for Adana (87.3 µSv y^{-1}), Konya (132.9 µSv y^{-1}), Kırklareli (144.7 µSv y^{-1}), Adıyaman (177.0 µSv y^{-1}), and Nevşehir (219.07 µSv y^{-1}) [15,21,23,26,28]. Conversely, the estimated AEDE for Gaziantep exceeds the values reported for Osmaniye (50.1 µSv y^{-1}), Tekirdağ (53.77 µSv y^{-1}), Çorum (55.14 µSv y^{-1}), and Bolu (27.23 µSv y^{-1}) [16, 24, 25 and 29]. Overall, the ADRA of 55.0 nGy h^{-1} and the corresponding AEDE of 67.5 µSv y^{-1} place Gaziantep within the moderate range observed across the selected Turkish regions, with the estimated annual dose remaining close to the global reference value. The observed regional variability is likely associated with differences in geological composition, soil characteristics, and the distribution of naturally occurring radionuclides across the investigated areas.

5. CONCLUSION

This study establishes a comprehensive spatial baseline of outdoor terrestrial gamma radiation across Gaziantep Province, Türkiye, based on an extensive field survey comprising 212 measurement locations. The measured absorbed dose rate in air (ADRA) ranged from 20.9 to 159.2 nGy h^{-1}, with a provincial mean of 55 nGy h^{-1}. The observed range demonstrates a distinct spatial heterogeneity in outdoor gamma radiation, indicating that local variations in the environmental and geological setting contribute to the distribution of terrestrial radiation across the province.

The corresponding annual effective dose equivalent (AEDE) was estimated at 67.5 µSv y^{-1}, remaining well below the 1 mSv y^{-1} reference level for public exposure specified by ICRP Publication 60 [40]. Moreover, the mean ADRA was lower than the global reference value of 60 nGy h^{-1} reported by UNSCEAR [1]. The estimated lifetime cancer risk values were 0.027, 0.030, and 0.034 according to the ICRP 103, BEIR VII, and ICRP 60 models, respectively. Despite the differences among the applied risk coefficients, the three approaches consistently indicate a relatively low radiological burden associated with outdoor gamma exposure in the investigated region.

The regional comparison further demonstrates that the radiological characteristics of Gaziantep are broadly consistent with the range reported for other regions of Türkiye, while its AEDE is close to the global reference value. The comparatively moderate radiation levels are consistent with the predominance of sedimentary and carbonate-rich lithologies, including limestone, marl, and Quaternary alluvial deposits, which are generally associated with relatively low terrestrial radionuclide inventories. At the same time, the occurrence of localized elevated ADRA values emphasizes that province-wide averages alone may not adequately represent small-scale spatial variations in environmental radiation. From a broader environmental radiation perspective, the present dataset provides an important spatially resolved reference framework for Gaziantep Province. The integration of systematic in situ measurements, dose assessment, lifetime cancer-risk estimation, and spatial mapping provides a robust basis for subsequent environmental radiation surveys and regional comparisons. Under the measurement conditions investigated, the results do not indicate a significant radiological concern for the general population arising from outdoor terrestrial gamma radiation. Nevertheless, continued spatially and temporally resolved monitoring would be valuable for identifying long-term variations in natural background radiation and for detecting localized changes associated with environmental or geological processes. The baseline established in this study can therefore serve as a reference for future radiological surveillance, environmental assessment, and long-term management of natural radiation exposure in southeastern Türkiye

AUTHOR DECLARATION

The author declare that this study was not generated by artificial intelligence, that its scientific content and intellectual responsibility belong entirely to the authors, and that they accept full responsibility for all scientific, ethical, material, moral, and legal consequences arising from the work.

AUTHORS’CONTRIBUTIONS

Muhammet Karataşlı: Conceived and designed the study; carried out the field-based radiometric measurements; performed data processing, statistical analysis, and spatial mapping; interpreted the results; and prepared, critically reviewed, and approved the final manuscript.

CONFLICT OF INTEREST

The author confirms that no financial, professional, or other personal interests were involved that could have affected the conduct, analysis, interpretation, or presentation of the research findings.

FUNDING

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ETHICAL APPROVAL AND PERMISSIONS

This study involved field-based environmental radiation measurements and non-invasive analytical procedures and did not involve human participants, animal experimentation, or restricted biological materials. Accordingly, institutional ethical approval and specialized regulatory authorization were not required for the procedures conducted in this study.

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