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Research Article

Radioecological Survey and Background Radiation Assessment of Open Areas in Tskaltubo, Georgia

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Abstract

Background: Natural background radiation is the principal source of ionizing radiation exposure to the global population, with radon and its decay products contributing the largest share. In Georgia, elevated natural radiation levels are expected due to uranium-bearing geological formations. The Tskaltubo resort zone is renowned for its radon-rich mineral waters, making it an important site for radioecological monitoring.

Objective: This study aimed to systematically measure and assess outdoor radiation background levels across the Tskaltubo resort zone to evaluate potential health implications for residents and visitors.

Methods: A total of 460 radiation background measurements were conducted in accordance with standardized protocols using the CPi-68-01 device. Measurements were taken at three active radon sources (№1, №2, №6) and surrounding open areas. Data were analyzed with independent-samples t-tests to determine significant differences between sites.

Results: Measured radiation background levels ranged from 60.5 to 85.2 nGy/h. The highest mean value was observed near radon source №1 (85.2 ± 3.11 nGy/h), corresponding to an annual effective dose of 0.75 mSv. Radiation levels near source №1 were significantly higher than those near source №6 ($p = 0.003$), source №2 ($p = 0.015$), and open resort areas ($p < 0.001$).

Conclusion: Outdoor radiation levels in the Tskaltubo resort zone remain below the 1.0 mSv/year public exposure limit, suggesting no immediate health risk from external exposure in open spaces.

However, as indoor environments typically contribute more to total population dose, further studies on indoor radon and γ-radiation levels are warranted.

Keywords: Background Radiation; Radon; Radioecology; Tskaltubo; Environmental Health; Georgia; Radiation Safety

Introduction

The ecological background of an environment includes multiple abiotic factors, among which ionizing radiation is one of the most significant. Over the past decades, background radiation levels worldwide have been influenced by both natural processes and anthropogenic activities. Large-scale incidents such as the Fukushima disaster have demonstrated the potential for localized accumulation of radioactive isotopes in water and soil. Moreover, climate-driven geological changes have led to increased radon emissions in some regions.

Globally, natural sources account for approximately 70–90% of the annual effective radiation dose, with radon and its decay products representing about half of this exposure. Chronic exposure to low doses of ionizing radiation is now recognized as a contributing factor to genetic instability and may influence long-term cancer risks.

Georgia's geological characteristics—particularly its uranium-bearing rock formations—lead to elevated natural background radiation levels compared to many other regions. Tskaltubo, an internationally known balneological resort, is notable for its radon-rich mineral waters used in medical balneotherapy. While these waters are considered therapeutic, their role in contributing to environmental radiation levels remains under-investigated.

This study provides a systematic survey of open-area radiation background in Tskaltubo, establishing a baseline dataset and evaluating potential public health impacts.

Materials and Methods

- **Study Area:** The study was conducted in the Tskaltubo resort zone, which contains multiple radon water sources, of which only sources №1, №2, and №6 remain operational (The study was conducted in 2023).
- **Measurement Procedure:** Radiation background levels were measured using the CPπ–68-01 device, calibrated according to manufacturer standards. Measurements were taken at a height of 1 meter above ground level. Data collection was carried out under comparable weather conditions to minimize variability.

A total of 460 measurements were distributed as follows:

Source №1: 110 points, Source №2: 80 points, Source №6: 120 points, Surrounding open areas: 150 points (Chart 1).

Statistical analysis

Mean radiation levels (M±m) were calculated for each location. Pairwise independent-samples t-tests were performed to compare site-specific radiation levels. Statistical significance was set at $p < 0.05$.

Results

Measured radiation background levels in the Tskaltubo resort zone varied from 60.5 to 85.2 nGy/h (Table). The highest mean radiation was observed near radon source №1 (85.2 ± 3.11 nGy/h), corresponding to an estimated annual effective dose of 0.75 mSv. Source №2 showed intermediate levels (72.1 ± 3.96 nGy/h, 0.63 mSv/year), while source №6 had slightly lower levels (68.2 ± 4.25 nGy/h, 0.60 mSv/year). Open resort areas exhibited the lowest background radiation (60.5 ± 4.78 nGy/h, 0.53 mSv/year).

Pairwise comparisons using independent-samples t-tests indicated that radiation levels near source №1 were significantly higher than those near source №2 ($t(188) = 2.45$, $p = 0.015$), source №6 ($t(228) = 2.99$, $p = 0.003$), and open resort areas ($t(258) = 4.32$, $p < 0.001$), indicating rejection of the null hypothesis for these comparisons. No significant difference was observed between sources №2 and №6 ($t(198) = 1.02$, $p = 0.31$), consistent with failing to reject the null hypothesis.

These findings suggest a clear spatial gradient, with the highest radiation levels concentrated near source №1 and gradually decreasing toward other sources and open areas. The measured outdoor radiation levels, while slightly elevated compared to typical global background levels (average 50–60 nGy/h), remain below the 1.0 mSv/year public exposure limit recommended by the International Commission on Radiological Protection (ICRP, 2007).

Discussion

This study demonstrates that outdoor radiation background in the Tskaltubo resort zone is elevated relative to global averages, particularly near radon source №1. Elevated radiation is likely associated with the uranium-bearing geological formations in the region and the proximity to active radon water sources, consistent with previous studies reporting high radon concentrations in Tskaltubo mineral waters [1,2]. The gradient observed among the measured sites indicates that localized radon emissions significantly influence outdoor radiation levels. Although the highest annual dose (0.75 mSv/year near source №1) remains below the 1.0 mSv/year public exposure limit, these findings emphasize the need for regular monitoring, particularly in areas with high tourist activity. Comparisons with international studies show that Tskaltubo's outdoor radiation is moderately elevated but still within safe exposure levels reported in similar geochemically active regions, such as parts of Finland and certain areas of Japan [3,4]. These comparisons further support the conclusion that the observed radiation levels in Tskaltubo are consistent with natural background variations typical for regions with uranium-bearing geological formations. It is important to note that this study only assessed outdoor radiation. Indoor environments, where individuals spend most of their time, may have higher radon concentrations, potentially contributing more to the total effective dose [5]. Therefore, further studies should focus on indoor radon monitoring, seasonal variations, and occupational exposure for resort staff. Longitudinal monitoring would also allow the assessment of temporal trends and the effectiveness of any mitigation measures. Overall, these results establish a baseline dataset for environmental radiation in Tskaltubo and provide evidence to guide public health recommendations and radiation safety management in the region [6-9].

Conclusion

This study provides the first systematic survey of open-area radiation background in the Tskaltubo resort zone. Radiation levels ranged from 60.5 to 85.2 nGy/h, resulting in annual doses below the 1.0 mSv/year public exposure limit. The highest levels were recorded near source №1, showing statistically significant differences from other measured areas.

This can be explained by the fact that radon water from source №1 emerges directly from the ground and is supplied to patients, whereas water from the other sources flows through special pipes before reaching consumers.

We estimated the external radiation dose to the population, which is unlikely to exceed an average annual dose of 0.4 mSv. This suggests that the existing radiation background is safe for public health. However, it should be noted that our study only assessed the radiation background level in open areas. To determine the total external radiation dose to the population, it is also necessary to assess the radiation background inside buildings, where people spend much more time (approximately 80% of their day and night). Consequently, the radiation dose from indoor exposure is expected to be relatively higher.

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