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ASSESSING GAMMA DOSE RATES: AIRBORNE NATURAL RADIOACTIVITY MEASUREMENTS IN ALBANIA

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Abstract. *Our study's main objective is to evaluate gamma dose rates in the air across the Republic of Albania. The Institute of Applied Nuclear Physics set up six monitoring stations in different parts of the country to measure how much radiation is present each month and year, and to figure out the total yearly exposure to natural radioactivity in the air. The monitoring system employed for gamma radiation is the GMT-based Gamma Dose Rate Monitoring System. The research has shown that the average radiation level for Albania is about 1.61 µSv ± 0.010 µSv/h, and the yearly estimate is around 587 µSv ±0.01 µSv/h. One interesting finding is that for three years in a row, Elbasan had the highest radiation reading, reaching up to 3,477 µSv. This number changed depending on the time of year, with the highest levels often happening during rainy days. These findings provide a baseline for monitoring environmental radioactivity and informing public health policies.*

Keywords: *radiation monitoring, natural background radiation, environment, population doses, Albania*

1. Introduction

Nearly 75% of the radiation dose to the public originates from natural background sources, primarily from radionuclides present in the soil and air [1]. Monitoring these sources is critical for understanding their impact on human health and the environment. The concentration of radioactive isotopes in the soil reflects environmental accumulation, influencing radiation levels experienced by humans, plants, and animals [8]. Seasonal variations also affect gamma radiation levels; for example, Pate et al. [10] observed that lithology had no significant effect during summer but showed a stronger correlation with gamma dose rates in winter, possibly due to soil moisture and precipitation effects. [10] but Cortes et al. said that precipitation causes a noticeable increase in environmental gamma-ray intensity at the ground surface. To support the theory, they built an online gamma spectroscopy system for rainwater. The operation of this device, which has been automated through a Lab View program, consists of the following steps: first, 250 cm^3 of water is collected and, if the rain rate is high enough, is transferred to the measurement tank, a Marinelli-like container located underneath an HPGe solid-state detector. All the system is surrounded by a lead shield. Preliminary measurements carried out with this device yielded radon daughter concentrations ranging from 50 Bq/1 up to 1600 Bq/1 [12] later in 2009 Mercier said. We have shown that the relative fluctuation in the increase of gamma-ray dose during rain periods can be predicted using a model that assumes the simple deposition, and decay, of radon progeny on the ground [11]. Rain temporarily increases gamma activity due to radon daughters, Pb-214 and Bi-214, being carried to the ground by raindrops. A seven-month study showed gamma monitoring effectively estimates rain-induced variations, with 214 Pb count rates strongly correlating with rain rates $r^2 = 0.91$. Lower rainfall intensity results in higher 214 Pb content for the same total rainfall [7]. Recognizing the magnitudes and patterns of radionuclide concentrations in the atmosphere holds substantial importance, as it imparts valuable insights for overseeing environmental radioactivity based on the currently available information, there is a lack of data regarding the levels of radioactivity in Albania. This study primarily aims to measure the gamma dose rate in the air.

Figure 1. ENVINET Geiger-Müller detector used for gamma dose rate monitoring in Albania.

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This measurement will be conducted using a network of 6 detectors strategically placed across the entirety of the Albanian territory. The basis for their establishment in the territory of Albania is decision no. 700, dated 21.11.2018 [4] on adopting the regulation "On preparation and response in case of radiological emergency for the protection of employees and public" Article 9 point 3. This dataset establishes a foundation for future monitoring programs aimed at detecting changes in natural and artificial radioactivity.

2. Materials and methods

2.1. Sample collection and preparation

Albania is a small country with mountains and hills in the east and marshland in the west. It is located between Southeastern and Southern Europe, on the Adriatic Sea and the Ionian Sea. The total area of Albania is 28,748 square kilometers, and has 4 state borders [2] with Montenegro to the northwest, Kosovo to the northeast, Macedonia to the east, and Greece to the south. Surrounded by two seas, it has a long coastline of 476 km (240 mi) [2]. Since Albania does not have a nuclear power plant (CB) in its territory, several CBIs near Albania are currently in operation, such as CB of Kozloduy and Cernavoda in Romania and Krsko in Slovenia. These CBs are located at different distances from Albania and necessitate monitoring for potential cross-border influences [4]. To monitor gamma dose rates, six detectors were strategically placed in major urban centers (Korça, Gjirokastër, Shkodra, Durrës, Elbasan, and Tirana) to provide comprehensive coverage of the country. These ENVINET Geiger-Müller detectors operate within a GMT-based monitoring system, capable of measuring both low and high dose rates. These detectors are part of a network designed for detecting radiation early, but they also have a secondary role in assessing the levels of gamma dose rate in the air when there's no emergency.

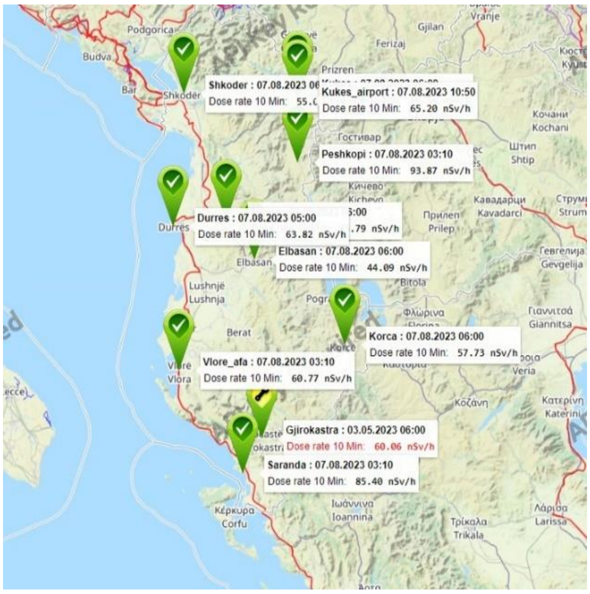


Figure 2. Geographic distribution of gamma dose rate detectors in Albania. Detectors are strategically placed in key urban centers to provide optimal national coverage, including Korça, Gjirokastër, Shkodra, Durrës, Elbasan, and Tirana.

In 2022, five more detectors were deployed with the project in collaboration with the Ministry of Defense. The location of the detectors is two in the city of Kuks and one in the cities of Bishop, Vlora, and Saranda. Two detectors with different quality are in Kukes, one total gamma, and the other the range spectrometer because even the nearer city with the nearer NPP is Kozloduy NPP, Bulgaria NPP Krsko in Slovenia, as well as Pks in Hungary [4]. The map of the detector's location is shown in the figure. Each of these detectors has its unique five-digit code corresponding to a specific location.

These stations are typically set up on the roofs of various buildings like hospitals and universities. But the newer sensors have found their home in military bases near meteorological stations. All the data these detectors collect are sent to a central server that gathers and stores all the information. To connect to this central server, each detector uses a SIM card that connects to the internet. This ensures that the measurements they take are accurate and up to date. To enhance data reliability, annual calibrations were performed using Eu-152 and Cs-137 sources, following the manufacturer's guidelines. Since the established stations are in state and military institutions, we ensure continuous operation during the 12 months of the year. The chances of the detectors being disturbed or moved are almost negligible because they are areas with limited public access. The Ministry of Defense supplies electricity for station operations. The Institute of Applied Nuclear Physics gives the required data and ensures it is functional and calibrated.

Figure 3. MIRA detector installed in Kukës. Positioned on secure building rooftops, these detectors minimize environmental interference while ensuring real-time data collection.

2.2. Gamma-ray detector

We measured gamma radiation with ENVINET's Geiger-Müller detectors. The detectors produced by the company ENVINET are used to determine if there will be an increase in the level of radiation due to unnatural causes, but also to determine the level of natural ionizing radiation in areas of interest. The radiological sensors consist of two Geiger-Mueller counting tubes, one with a large-volume detector for low dose rates and another smaller tube for detecting higher dose rates. Two Geiger-Mueller (GM) detectors provide a wide range of detection from natural background up to > 10 Sv/h (Sieverts per hour). The low-dose rate detector (LD) enables the detection of small changes in radiation at background levels within short detection cycles. The second detector's high dose (HD) is used to measure higher dose rate levels (>100 µSv/h The hermetically sealed housing of the detectors protects the electronics and detectors from external conditions. To avoid being controlled by temperature, the detectors are filled with Argon. Every year, the efficiency calibration is performed using the standard source Eu-152 or Cs-137. Everything is controlled through the MIRA application, which aims to quickly verify the latest status of the detector and the measured gamma dose rate, analyze historical values, and perform accuracy/reference tests of the MIRA probes via Bluetooth connection.

The total number of pulses from the GMT(s) and the temperature are acquired at the real-time border of the base interval.

$$\dot{D} = \dot{D}_0 - \dot{D}_{\text{self-effect}} - \dot{D}_{\text{loc}}$$

$\dot{D}_0$: Dose rate, calculated from the dead-time corrected count rate.

$$D_0 = \frac{n}{e} \cdot \frac{1}{1 - n \cdot \tau}$$

where n count rate observed during the base interval [cpm] e sensitivity [cpm / µSv/h] τ dead time constant [1 / cpm]. $\dot{D}$ self-effect: The temperature-dependent self-effect compensation is performed using:

$$\dot{D}_{\text{self-effect}} = \dot{D}_{\text{null}} + \frac{1}{e} \cdot \left(p1 + \frac{1+p_2 \cdot (T+p_3)^2}{1+p_4 T}\right)$$

The temperature correction is generally limited to 10 nSv/h (excluding the contribution of $\dot{D}_{\text{null}}$). $\dot{D}_{\text{loc}}$: User-defined location correction (default: 0) The count rate n is defined as $n = N\, t/r$, where N is the number of recorded counts and tr the real-time of the base interval.

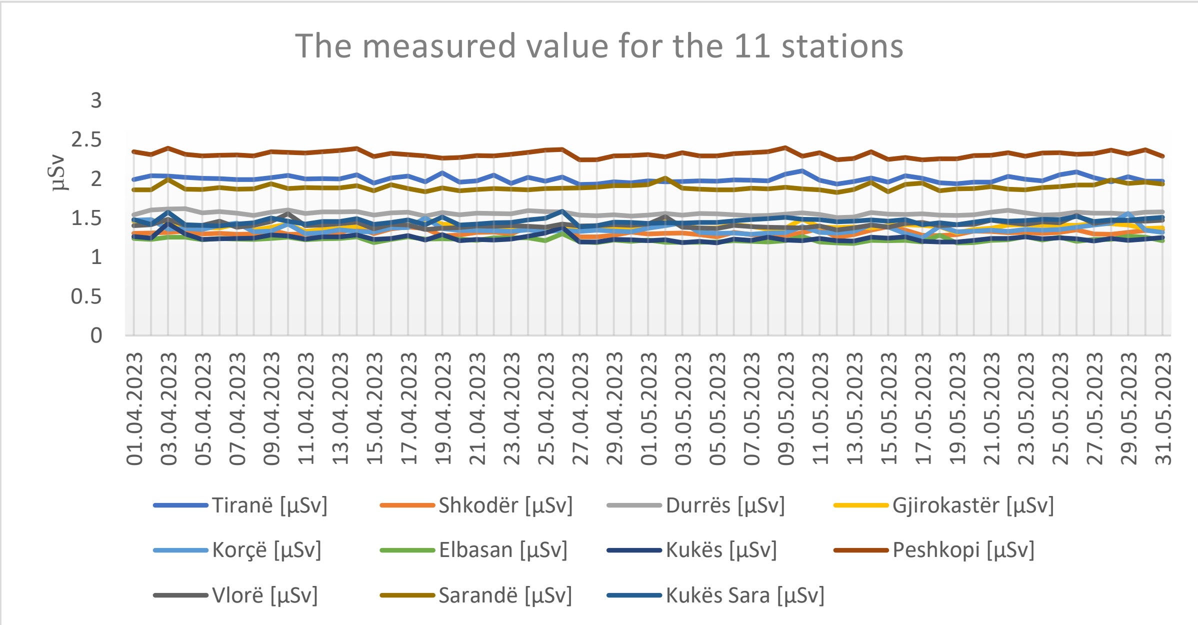


Figure 4. Presentation of the data measured by the MIRA and SARA detectors for April 2023 [5]

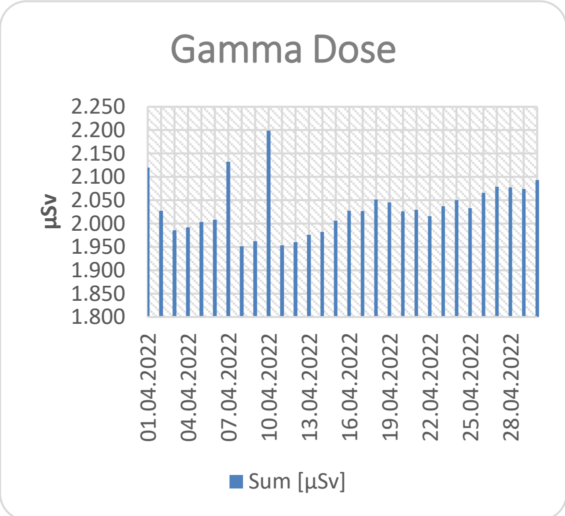
3. Results and discussions

During the 3.5-year observation period, the gamma dose rate in Albania showed minimal fluctuations from year to year. The highest recorded value occurred in 2021, while the lowest was in 2022. The national average dose rate was 1.61 µSv/h, with the region of Elbasan consistently presenting the highest levels. Notably, in 2021, Elbasan reached a peak value of 3,477 µSv/h, which aligns with seasonal precipitation events. These conditions likely contributed to increased deposition of radon progeny, particularly isotopes such as Pb-214 and Bi-214 [3]. The analysis of gamma dose rates across Albania reveals notable findings. Table 1 highlights the yearly averages and extremes, with Peshkopia standing out as a strong outlier. This anomaly is likely attributed to its proximity to a former uranium mine, emphasizing localized influences on dose rates. Additionally, spikes in gamma dose rates during rainfall support conclusions from other studies that precipitation amplifies ground-level radiation by enhancing the deposition of radionuclides. Figure 5 illustrates this effect in detail, showcasing the variation in gamma dose rates during April 2022 in Tirana.

Table 1. Yearly averages and extremes of gamma dose rates in Albania (2020–2023).

µSv	2020	2021	2022	2023
Average	1.706	1.5951	1.521	1.6325
Max	3.134	3.477	2.344	2.399
Min	1.18	1.18	1.58	1.174

Significant increases were observed on rainy days, followed by a gradual return to baseline values under dry conditions. This pattern underscores the sensitivity of radiation levels to weather conditions, reinforcing the need to consider meteorological factors in radiological assessments. In Figure 4, we have presented the radiation value measured by all detectors. Due to the country effect, we could not complete all the measured values. In Table 1, the cities of Peshkopia, Tirana, and Saranda are the cities with the highest value of natural radiation. Therefore, we have considered the month of April 2023. From the values taken, the city of Peshkopia is significantly above the national average. This could also be because, in the vicinity of the city of Peshkopia, there is also a former uranium mine in Albania. In Figure 5, we have presented the change of gamma radiation depending on the days for the city of Tirana. To present this change, we have taken into consideration the month of April 2022. According to the data from World Weather [6], on April 7 and 10, where we had almost double the level of radiation, it happened because of the heavy rain that fell that day [6].



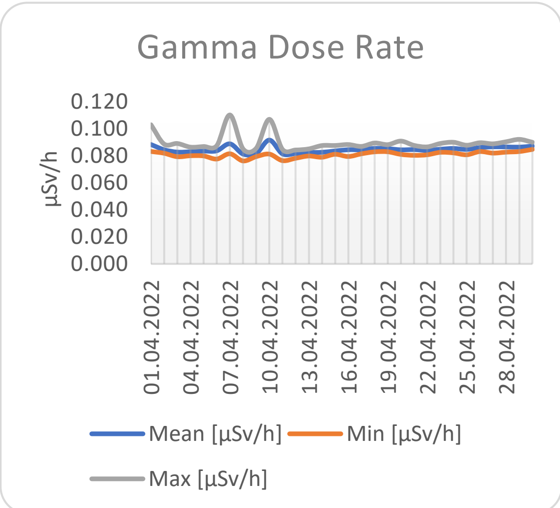


Figure 5. (a) shows the daily value of gamma radiation measured for Tirana, and (b) shows the gamma dose rate measured for Tirana.

The water has particles of radiation in the upper layers and comes down in the form of rain. On the other hand, the first part of the month has been cloudier, and the radiation is a little lower than average. After April 13, we have sunny weather again, which brings an increase in the level of ionizing radiation around the average value. Again, for the time effect, the month of April was chosen, but this time the year 2022. In Figure 5b, we have presented the dose rate in µSv/h. It also presents the max and min values. Another important aspect of the results is the constant value of the measurements taken, the minimal deviation from the national average, and the average taken for the background of natural radiation adequately represents the national average.

4. Conclusion

This study confirms that airborne gamma dose rates in Albania remain within safe limits, with an average annual dose of 1.634 mSv/year, significantly below the global average of 2.41 mSv/year and the European average of 3.20 mSv/year. Elbasan's consistently higher dose rates highlight the need for continued monitoring in regions with specific geological and environmental features [5] The data collected establishes a robust baseline for future environmental radioactivity assessments and informs public health initiatives. Seasonal variations, particularly during rainy periods, emphasize the importance of incorporating meteorological factors into monitoring frameworks. Expanding this study to include comparisons with neighboring countries and additional data on soil and water radioactivity will further enhance understanding of Albania's radiation profile.

References

1. K. S. V. Nambi et al., *Natural background radiation and population dose distribution in India*, Bhabha Atomic Research Centre, Bombay, India, 1986.
Retrieved from:
https://inis.iaea.org/collection/NCLCollectionStore/_Public/20/084/20084715.pdf
Retrieved on: Aug. 8, 2023
2. *Atlas of Albania*, Commons Wikimedia, a, San Francisco (CA), USA, 2022.
Retrieved from:
https://commons.wikimedia.org/wiki/Atlas_of_Albania
Retrieved on: Jan. 16, 2022
3. *Copernicus: 2022 was a year of climate extremes, with record high temperatures and rising concentrations of greenhouse gases*, ECMWF/ Copernicus Climate Change Service, 2022.
Retrieved from:
https://climate.copernicus.eu/copernicus-2022-was-year-climate-extremes-record-high-temperatures-and-rising-concentrations
Retrieved on: Apr. 1, 2022
4. Qeveria e Shqipërisë. (Nëntor 21, 2018). *Vendim nr. 700 për miratimin e rregullores "për përgatitjen dhe reagimin në rast emergjence radiologjike për mbrojtjen e punonjësve dhe të publikut"*.
(Government of Albania. (Nov. 21, 2018). *Decision no. 700 for the approval of the regulation "for the preparation and response in the case radiological emergency for the protection of employees and the public"*)
Retrieved from:
https://shendetesia.gov.al/wp-content/uploads/2019/02/VKM-nr.-700-date-21.11.2018.pdf
Retrieved on: Apr. 1, 2022

5. G. Cinelli et al., “Digital version of the European Atlas of natural radiation,” *J. Environ. Radioact.*, vol. 196, pp. 240 – 252, Jan. 2019.
   DOI: 10.1016/j.jenvrad.2018.02.008
   PMid: 29496295
   PMCid: PMC6290173
6. *Weather in Tirana in April 2022*, World Weather, 2022.
   Retrieved from:
   https://world-weather.info/forecast/albania/tirana/april-2022
   Retrieved on: Apr. 1, 2022
7. N. Kadhim, *Radioactivity*, ResearchGate, Berlin, Germany, 2020.
   Retrieved from:
   https://www.researchgate.net/publication/339831191_Radioactivity
   Retrieved on: Aug. 8, 2023
8. D. Shahbazi-Gahrouei, M. Gholami, S. Setayandeh, “A review on natural background radiation,” *Adv. Biomed. Res.*, vol. 2, no. 1, p. 65, 2013.
   DOI: 10.4103/2277-9175.115821
9. S. S. Duhan, P. Khyalia, J. S. Laura, “A comprehensive analysis of health risk due to natural outdoor gamma radiation in Southeast Haryana, India,” *Curr. Sci.*, vol. 123, no. 2, pp. 169 – 176, Jul. 2022.
   DOI: 10.18520/cs/v123/i2/169-176
10. D. Patel, M. K. Jindal, P. S. Pamidimukkala, D. Chakraborty, “Gamma radiation dose rate distribution in the Anand, Bharuch, Vadodara, and Narmada districts of Gujarat, India,” *Environ. Sci. Pollut. Res.*, vol. 30, no. 49, pp. 107104 – 107117, Oct. 2023.
    DOI: 10.1007/s11356-023-25711-4
    PMid: 36807856
11. J. F. Mercier et al., “Increased environmental gamma-ray dose rate during precipitation: A strong correlation with contributing air mass,” *J. Environ. Radioact.*, vol. 100, no. 7, pp. 527 – 533, Jul. 2009.
    DOI: 10.1016/j.jenvrad.2009.03.002
    PMid: 19403214
12. G. Cortes, J. Sempau, X. Ortega, “Automated measurement of radon daughters Bi-214 and Pb-214 in rainwater,” *Nukleonika*, vol. 46, no. 4, pp. 161 – 164, 2001.
    Retrieved from:
    http://www.ichtj.waw.pl/ichtj/nukleon/back/full/vol46_2001/v46n4p161f.pdf
    Retrieved on: Aug. 8, 2023