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Measurement of background radiation in Jhapa, Ilam, Panchthar, and Taplejung districts of Nepal

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Abstract

In this study, we investigated the levels of background radiation in different locations across the Eastern part of Koshi province, specifically in Taplejung, Panchthar, Ilam, and Jhapa. We used a portable Geiger Muller counter to collect data from twenty different locations, with five sites taken from each district. The average absorbed dose rate was found to be 0.243±0.035 mSv/y. The highest measured value of absorbed dose was 0.335±0.041 mSv/y at Pathivara temple in Taplejung, and the lowest was found to be 0.197±0.039 mSv/y at Kakarvita, Jhapa. The results suggest that these four districts do not pose any radiation risk because it was below the threshold of risk (1mSv/y). We also measured the variation of absorption dose with altitude which is positively correlated with altitude with a correlation coefficient of +0.57. This might be because of the surge in cosmic radiation with an increase in altitude.

Keywords
Onizing radiation, Cosmic radiation, Absorbed dose, G.M. Counter, Background radiation.

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1 Introduction

Background radiation measurement is an important task to evaluate dose for general people due to various sources. These sources are categorized into three groups: primordial, cosmogenic, and human-produced, with the most abundant being naturally occurring radionuclides (i.e. Primordial radionuclides) [1–4]. These radionuclides exist in each rock, soil, and water and significantly vary depending upon geological and geographical situations. Cosmic radiation is a significant contributor to the radiation entering the earth's atmosphere from its surroundings. The amount of cosmic radiation that reaches the earth's surface varies depending on a number of factors, such as altitude, latitude, and solar activity [5]. In addition to these sources, the background radiation at the local level is also greatly affected by the presence of man-made sources, such as those from nuclear activities and accidents [6].

There are various regulatory bodies such as the Nuclear Regulatory Commission (NRC) and the International Atomic Energy Agency (IAEA) that set standards for radiation exposure to ensure the safety of individuals working with radiation or living near nuclear facilities. These agencies also monitor background radiation levels to ensure they remain within safe limits [7–9].

There are several international studies reported in the literature for the measurement of background radiation levels both in outdoor and indoor areas, and the global average value for dose rate is 59 nGy/h with the range of $18 - 93$ nGy/h [10, 11].

The first preliminary ground radiometric survey in Nepal was conducted in 1977/1978 and confirmed the presence of deposition of the mineralized bodies in Tinbhangale, Makawanpur. Pantha et al. (2018), Gautam et al. (2020), Dhami et al. (2020), and Shrestha et al. (2023) conducted the radiometric survey in Pokhara Valley, Kathmandu, Kanchanpur, and Morang district, respectively [12–15]. Results showed that these areas are under normal background radiation. In Nepal, there are 77 districts; therefore, the comprehensive investigation to assess background radiation levels across the country is the most important and immediate concern to the general population [16] because no further works have been obtained in the literature. Similarly, people living in high-altitude regions are receiving a higher dose of radiation, but it has a lack of information. Therefore, this study was carried out to provide a map of background radiation using a GM detector in eastern Nepal and to estimate the annual effective dose of residents in these areas. Such works become very useful for locating the high background radiation area. It is also a regulatory prerequisite for installing and operating a research reactor and nuclear power plant and testing nuclear weapons.

2 Materials and Methods

2.1 Description of Instrument

The data collection in this study was performed using the GM counter model GMC-300E plus, which employs a GM tube to detect nuclear radiation. The GM tube is designed to detect radiation by producing an electric current pulse when ionization occurs due to the passage of radiation through the tube. The instrument then detects and records each pulse as a count. The GMC-300E plus is a highly portable and battery-operated device that offers three different modes for displaying the counts: counts per minute (CPM), milliroentgen per hour (mR/h), and microsievert per hour (μSv/h).

It is worth noting that the GMC-300E plus is capable of detecting high-energy x-rays ($0.03 - 3.0$ MeV), beta particles ($0.25 - 3.5$ MeV), and gamma rays ($0.1 - 1.25$ MeV). This makes it an ideal device for monitoring a wide range of nuclear radiation sources in different settings. The portability of the instrument allows for easy transport, enabling data collection to be performed on-site or in the field. The three different modes of display provide flexibility in the analysis of the collected data, making it easier to compare the results with existing radiation safety standards. For quality control measures, some specifications of the instrument are shown in Table 1.

2.2 Study Area

The present study comprises data collected from the Eastern part of Nepal, encompassing four distinct districts, namely Jhapa, Ilam, Panchthar, and Taplejung. The total area of the site under consideration is approximately 8196 square kilometers. The geographical expanse of the region can be broadly classified into three categories, viz., the mountainous terrain, the central hilly region, and the lower terrain (plain) region. The pinnacle of the region is the Kanchenjunga peak, situated in Taplejung, with an altitude of 8586 meters, while the lowest is marked by Kechana Kalan, located in Jhapa, with an elevation of merely 60 meters. The highest point of elevation, from where the data has been gathered, is Pathivara, situated at a height of 3780 meters. On the other hand, the lowest altitude, where data collection was undertaken, is an altitude of 92 meters, which is at Kakarvita in Jhapa. The study area with the sampling locations in four districts is given in Fig. 1.

Table 1: Specifications of the GM counter model GMC-300E plus

Specifications:

- Range of dose rate indications, µSv/h: 0.00 to 327.99
- Range of gamma radiation energy MeV: 0.1 - 1.25
- Range of registered beta radiation energy MeV: 0.25 - 3.5
- Range of registered X-ray radiation energy MeV: 0.03 - 3.0
- Reproducibility of indication: 15~20%
- Alarm levels by uSv/h: 0.00 to 327.6 (continuously)
- Timed Count: 1 Second to 256 days(programmable)
- Instrument Background: < 0,2 pulses/s
- Working Voltage: 3.6-3.7V
- Display: LCD dot matrix, back lighted
- On board Memory: 1M Bytes flash memory for data storage
- Power: Consumption: 25mW – 125mW (count rate dependant)
- Power: Supply: 3.7V Li-Ion battery / USB power from mains or car DC adapter

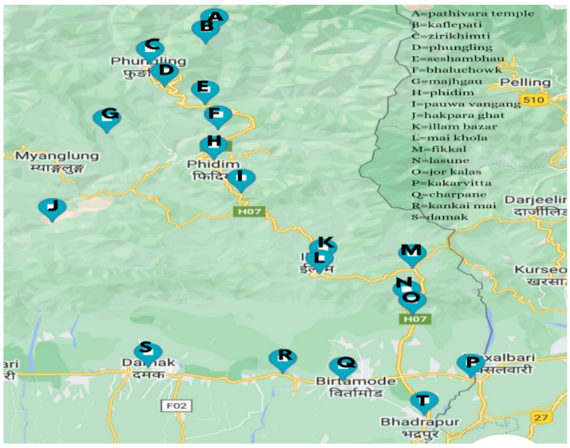

Figure 1: Study area with the sampling locations.

2.3 Measurement and Calculations

Data was collected in count per minute (CPM) 10 times from a location. For conversion of this data into mSv/y, Eq. (1) is used [17],

$$D(mSv/y) = (M \times 0.2 \times F \times 24 \times 365)\frac{1}{100} \quad (1)$$

where, D: absorbed dose rate in mSv/y
M: Measured value in Count Per Minute
F: Conversion Factor from CPM to μSv/hr
0.2 is the outdoor occupancy factor

After the conversion of all data, mean and standard deviation were calculated, and all data were plotted in an error bar graph.

3 Results and Discussion

The background radiation of the Taplejung district is presented in Fig. 2. The background radiation in count per minute was converted into an absorbed dose rate using Eq. (1). The lowest value was observed to be $(0.268\mp).03)mSv/y$ in Phungling and the highest dose rate $(0.335\mp).041)mSv/y$ was observed in Pathivara. It may be due to the effect of cosmic radiation at higher altitudes. The average background radiation of the Taplejung district was $(0.289 \mp 0.02)mSv/y$.

The background radiation of the Panchthar district is presented in Fig. 3. The lowest dose was found to be in Phidim, and the highest dose was observed in Pauwa Vangang. As a result, the mean background radiation of the Panchthar district was $(0.247 \pm 0.056)mSv/y$. The background radiation of the Ilam district is presented in Fig. 4. The minimum dose rate was in Jorkalash, and the maximum dose rate was in Ilam Bazar. The average background radiation of the Ilam district was $(0.225\pm0.015)mSv/y$. The background radiation of the Jhapa district is presented in Fig. 5. The lowest dose was found to be in Kakarvita, and the highest equivalent dose rate of was observed in Bhadrapur. However, the average background radiation of the Jhapa district was $(0.209 \pm 0.011)mSv/y$. All these values were below the recommended value of $1mSv/y$ set by the International Commission on Radiological Protection (ICRP) for non-radiation workers and the public.

The equivalent dose of all districts where the study is conducted is plotted in Fig. 6. The lowest equivalent dose rate $(0.209 \pm 0.011)mSv/y$ was found to be in Jhapa, and the highest equivalent dose rate $(0.280 \pm 0.026)mSv/y$ was observed in Taplejung. The average background radiation of the Eastern region of Koshi Province was $(0.242 \pm 0.034)mSv/y$. This result also supports the increase in background radiation with altitude. The average altitude of the study areas in Jhapa, Ilam, Panther, and Taplejung is 117, 1003, 1279, and 2110 m respectively. Jhapa being at lower altitude has low dose rate, and Taplejung, being at higher altitude, has a high dose rate. Variation of absorbed dose rate with altitude has been shown in Fig. 7. It shows that there is a positive correlation between altitude and absorbed dose rate, as altitude increases the exposure also increases, this might be due to the increase in cosmic radiation with an increase in altitude.

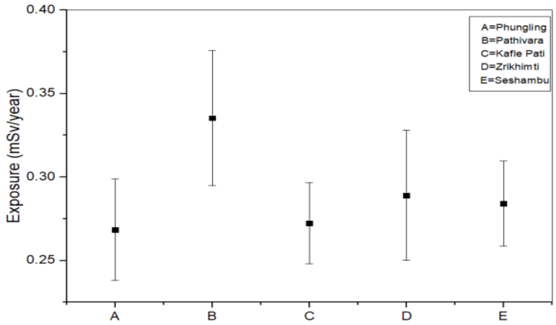

Figure 2: Background radiation of different parts of Taplejung district.

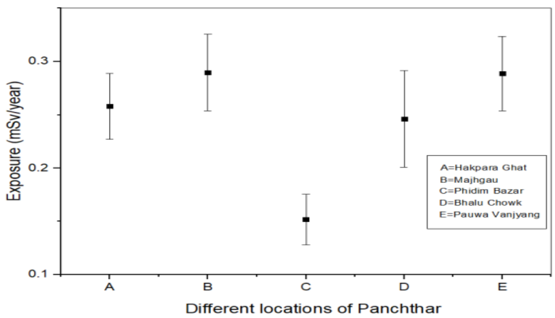

Figure 3: Background radiation of different parts of Panchthar district.

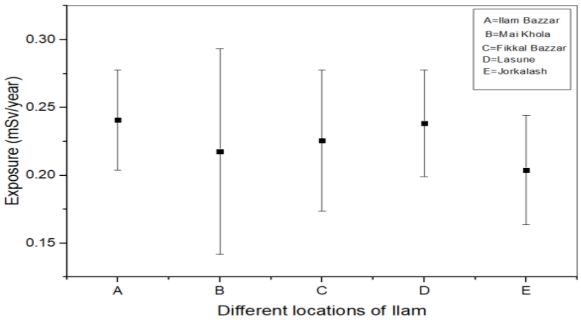

Figure 4: Background radiation of different parts of Illam district.

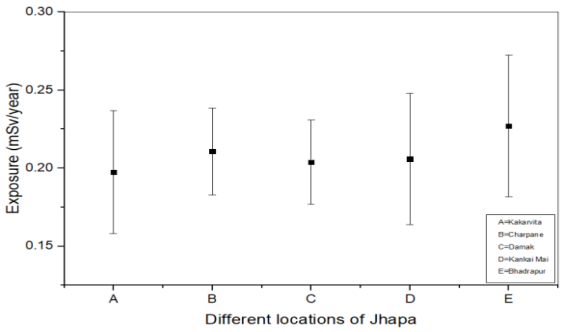

Figure 5: Background radiation of different parts of Jhapa district.

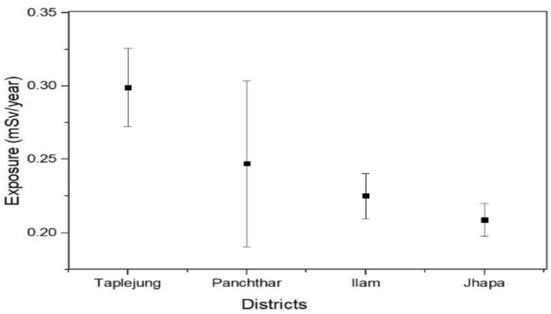

Figure 6: Comparative study of dose rate at different districts.

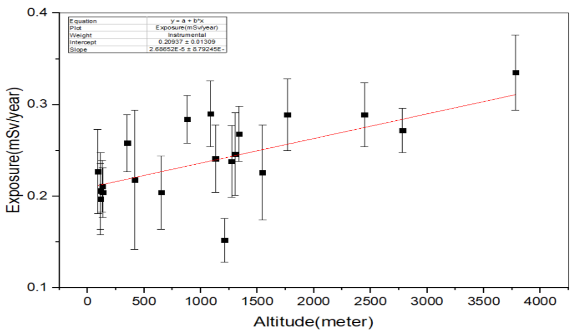

Figure 7: Variation of background radiation with altitude.

4 Conclusion

The study focused on measuring the natural background radiation dose at different locations in the Taplejung, Panchthar, Ilam, and Jhapa districts. A total of twenty locations were considered for the study, and the average dose rate for four districts was found to be $(0.24 \pm 0.25) mSv/y$. It is also observed that background radiation also increases with increasing altitude. It was determined that the annual effective dose value was lower than the legally prescribed dose limits for non-radiation workers and the general public, as set by the International Commission on Radiological Protection (ICRP). Therefore, the natural exposure level in Taplejung, Panchthar, Ilam, and Jhapa is not hazardous to the people residing in the study region.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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