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Preliminary Survey of Background Radiation Exposure in Koshi Province, Nepal

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Abstract

Exposure to high background radiation is the major cause of health risks such as cancer. So, it is the prime issue of recent research to monitor the background radiation at various parts of the country. In the present study, the background radiation of Koshi Province was measured using a portable G.M. counter model GMC-300 Plus. The result showed that the average background radiation of Koshi Province is 0.28±0.05 mSv/y. It is below the threshold limit of 1mSv/y for non-radiation workers and the public. The best-fit line between the background radiation and altitude showed a gradual increase in background radiation with altitude because of cosmic radiation.

Keywords: Koshi Province, Background radiation, GM counter, cosmic radiation, terrestrial radiation

Introduction

Radiation is present everywhere, and the primary sources of background radiation are primordial and cosmogenic radionuclides (Shrestha et al., 2024; Sannappa et al., 2003). The radiation produced by the artificial sources also significantly contributed to the background radiation in that place.The cosmogenic radiation originated from space, and itmainly consists of high-energy particles such as protons and nuclei that originate outside the solar system. The amount of cosmic radiation entering the Earth's surface varies due to altitude, latitude, and solar activity (Potgieter, 2013). On the other hand, the primordial radiation, which is also known as terrestrial radiation, originates from the presence of radionuclides of uranium, thorium, and potassium present on the Earth, and their concentrations vary from place to place (Eisenbud& Gesell,1997; Pooya et al., 2015). Due to local geological and geochemical affects that raise terrestrial radiation levels, a selected few locations worldwide are recognized as having high background radiation levels. Particular regions in Brazil, Iran, India, and China are said to be

affected by elevated backgr radiation (Ghiassi-Nejad et al., 2002; Alzubaidi, 2022; Upadhyay et al., 2024)

Exposure to high background radiation can cause various health risks, such as cancer. As a result,it is crucial to discover places with higher background radiation (Bhatt et al., 2012).Since Nepal is a diverse country, uranium has been found to be deposited in various locations, including the Shivapuri area (Kathmandu), Mustang, ChiruwaKhola (Makwanpur), Chadi Khola, Chamaliya River (Darchula), and Tinbhangale (Shah et al., 2002; Shah & Paudyal, 2019). Even though the mining of those places hasn't operated till now, the future mining operation cannot be ignored. In recent years, monitoring of background radiation has started in various parts of the country. The authors' team measured the background radiation in some districts of Koshi Province, such as Morang, Taplejung, Panchthar, Ilam, and Jhapain different time intervals (Shrestha et al., 2023a; Shrestha et al., 2023b). Other districts of Koshi province were untouchedby the prospect of radiation measurement.The present work focuses on the background radiation measurement and its variation with altitude in Koshi province of Nepal.

Materials and Methods

Koshi province consists of fourteen districts and is divided into three categories: mountains,hills, and plain (lower terrain). The highest peak of Koshi province is Mt. Everest, with an altitude of8848.9 m, while Kechana Kalan, Jhapa, is the lowest altitude of 60m.The highest point from where the data was taken is RatnageDanda, Solukhumbu, withan altitude of 3287m, and the lowest point from where the data was taken is Bantabari, Sunsari, with an altitude of 103 m.Both primary and secondary data were collected for the study of background radiation. The primary data were collected from four different locations in each district of Sunsari, Dhankuta, Terathum, Bhojpur, Sankhuwasawa, Udayapur, Khotang, Okhaldhunga, and Solukhumbu. The secondary data for the rest of the districts was obtained from our previous study to provide background radiation data for Koshi Province.

The data collection was performed using the G.M. counter model GMC-300 Plus. It is a battery-powered, incredibly portable device that can show counts in three distinct ways: milliroentgen per hour (mR/h), microsievert per hour (μSv/h), and counts per minute (CPM).The measurement was carried out five times from each location within the intervals of five minutes. The background radiation was expressed in terms of an annual effective dose using Eq. (1)(Begum et al., 2018),

$$D\ (mSv/y) = (M \times 0.2 \times 24 \times 365)\frac{1}{1000} \quad \ldots\ldots\ldots (1)$$

where, M = measured value in μSv/hr, and 0.2 is the outdoor occupancy factor.

Results and Discussion

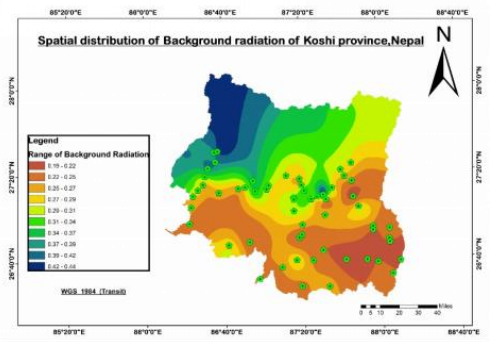

Figure 1. Spatial distribution of background radiation in Koshi province

The spatial distribution of background radiation is presented in Figure 1 and refers to how background radiation varies across a geographic area. It is often visualized through ArcGIS maps and influenced by factors like soil properties and altitude. Understanding this distribution is crucial for the protection of human health from unnecessary radiation exposure. In Figure 1, color variation represents the variation of the background radiation across the Koshi Province. Dark brown represents the lowest background radiation level, whereas dark blue represents the highest value. Overall, results showed that background radiation was highest in the mountain region and lowest in the plain region.

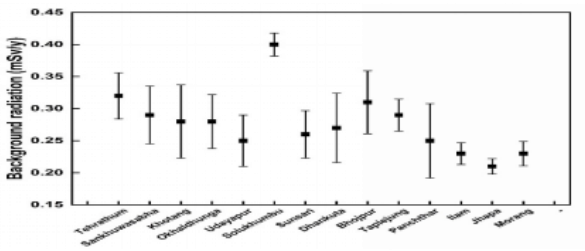

Figure 2.Average background radiation in different districts of KoshiProvince

The average background radiation in all districts of Koshi Province is presented inFigure2 with an error bar. The error bar represents the standard deviation of datapoints in each district. The background radiation was measured at various altitudesin each district, and it is significantly affected because of cosmicradiation. In Taplejung, Panchthar, Ilam, and Jhapa districts, data were measured in five different locations of each district,and in the rest of the districts of Koshi Province, data were taken only from four different locations.

In Taplejung district, the lowest background radiation (0.27±0.03) mSv/ywas observed in Phungling at a height of 1085m, and the highest dose rate of(0.33±0.04) mSv/y was

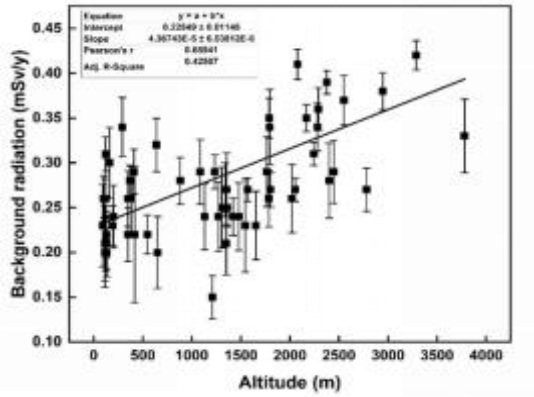

Figure 3. Variation of background radiation with altitude in Koshi

observed in Pathivara at a height of 3780 m, so that its average background radiation was 0.29 ± 0.03 mSv/y. In Panchthar district, the lowest dosewas (0.15±0.02) mSv/y in Phidim at an altitude of 1210 m, and the highest value of(0.29±0.03) mSv/y was observed in Pauwa Bhanjang at an altitude of 2445 m. As a result, the mean background radiation was 0.25±0.06 mSv/y. In Ilam, the minimumdose rate was (0.20±0.04) mSv/y in Jorkalash at a height of 651 m above sea level, and the maximum dose rate was (0.24±0.04) mSv/y in Ilam Bazar at a height of 1130m, with an average value of 0.22±0.01 mSv/y. The average background radiation inJhapa was 0.21±0.01 mSv/y and was almost constant in all sites of the district. Itmay be due to the nearly the same altitude in the district. In Sankhuwasabha, Bhojpur,Tehrathum, Dhankuta, Sunsari, and Morang districts, average background radiation was0.29±0.04, 0.31±0.04, 0.32±0.04,0.27±0.05, 0.26±0.04, and 0.23±0.02 mSv/y, respectively.

Similarly, average background radiation in Solukhumbu, Okhaldhunga, Khotang,and Udayapur districts of Sagarmatha Zone was 0.40±0.02, 0.28±0.04, 0.28±0.06, and0.25±0.04 mSv/y, respectively. Overall, the average background radiation of the KoshiProvince is 0.28±0.05 mSv/y. Among these districts, the highest radiation level was detectedin Solukhumbu and the lowest radiation level in Jhapa. The general pattern of the resultsshowed that the background radiation was highest in the mountainous districts such as Solukhumbu, Taplejung, Bhojpur, Tehrathum, and Sankhuwasabha and lowest valuein the plain districts such as Jhapa, Sunsari, Morang, and Udayapur. The background radiation is greatly contributed by the naturally occurring radionuclides and the cosmicradiation (Mishev& Hristova, 2012). Thehigh background radiation in the mountains and hilly regions is due to NORMs andcosmic radiation. At low-altitude

regions, cosmic radiation is mostly blocked by the Earth's atmosphereand does not have any significant effect on background radiation. All these values were below the recommended value of 1mSv/y set by the ICRP for non-radiation workers and the public (Charles, 2001). Therefore, people living in the study area are not at risk from the radiation level.

The variation of background radiation with altitude is demonstrated in Figure 3, withan error bar. In this case, an error bar represents the standard deviation from the meanvalue in thelocation. The result showed a significant correlation betweenthe altitude and background radiation, with a Pearson correlation coefficient of 0.66.Similarly, the adjusted R^2gives the degree of fitness of the observed data in the linearfit, and its value is only 0.44. This result indicates that 43% of data points fit the linearfit line.The best-fit line showed that the average background radiation at an altitude of 300 m was 0.24 mSv/y. While at an altitude of 3300 m, its average value was 0.37 mSv/y. It indicates an increment of background radiation by 0.04 mSv/y for every 1000 m altitudemay be the effect of cosmic radiation.

Table 1. Comparative study of background radiation levels indifferent parts of Nepal

SN	City/Country	Effective dose (mSv/y)	Authors
1	Koshi Province, Nepal	0.28	Present study
3	Kathmandu, Nepal	0.47	(Pantha et al., 2018)
5	Kanchanpur, Nepal	0.27	(Dhami et al., 2020)
4	Pokhara Valley, Nepal	0.81	(Gautam et al. 2020)
2	Morang, Nepal	0.24	(Shrestha et al. 2023a)

Table 1 depicts the comparative study of the present work with other works carried out in Nepal. It presented the background radiation levelspreviously measured in Morang, Kanchanpur, Pokhara, and Kathmandu districts. The lowest radiation level was 0.24 $\mu Sv/y$ and observed in Morang. Meanwhile, the highest radiation level (0.81 $\mu Sv/y$) was observedin Pokhara. Pokhara and Kathmandu are two cities situated in the hilly region and have higher radiation levels.However, Kanchanpur and Morang are in the same geographic region (plain) and have nearly the same radiation level. Overall, the background radiation of Koshi Province is slightly higher than that of the Morang and Kanchanpur districts.

Conclusion

The present study focused on measuring the background radiation level in different districtsof Koshi Province. Sixty different locations in all fourteen districts were considered for data collection for this purpose. The spatial distribution of background

radiation levels is presented through the ArcGIS map. The average background radiation of Koshi Province was 0.28±0.05 mSv/y, and it was lower thanthe prescribed limitsof 1 mSv/y for the public and non-radiation workers, as set by the ICRP. Therefore, the background radiation level in Koshi Province is not hazardousto all residing in this region. The best-fit line between the background radiation and altitude showed a gradual increase in background radiation with altitude because of cosmic radiation.

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