Measurement of natural background radiation level in Darchula district, Nepal

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Abstract: Natural background radiation level within Darchula district of Nepal was measured using a simple portable Geiger-Müller counter. Data were collected along six different directions at different places (three-five places) of the sample sites of the district and was averaged. The average data value with their standard deviation was used for analysis. In this study, the maximum radiation counts of 51.16 $\pm$ 2.30 CPM were reported at Satan and the minimum counts of 25.96$\pm$ 2.30 CPM at Gokuleshwar. The observed radiation level of the Darchula district shows that the district is below the radiation risk level (nearly 100 CPM).

Keywords: Background radiation; GM Counter; Darchula; ELF Radiation; CPM.

Introduction

In general, the word radiation is the energy emitted as the electromagnetic waves or subatomic particles and is present everywhere around us[1-3]. Radiation is produced from a variety of sources like; cosmic rays, terrestrial radiations, internal radiations, medical x-rays, etc. The majority of the radiation occurs naturally and it pervades the whole universe at all times. Broadly, there are two types of radiation: ionizing and non-ionizing radiation[4]. The high energy radiation or strong radiation having enough energy that can remove the tightly bound electrons from an atom forming ions is called ionizing radiation[1, 4, 5].

Some atoms are naturally stable while others are unstable. Atoms having unstable nuclei, called radionuclides, spontaneously transform into stable nuclei and release energy in the form of radiation. This energy can interact with other atoms and ionize them. Ionization is the process by which atoms become positively or negatively charged gaining or losing electrons. Ionizing radiation carries enough energy to make electrons free from their orbit resulting in the creation of charged atoms called ions. Ionizing radiations are emitted due to various phenomena like emission of two protons and two neutrons called as α-decay, emission of electrons called as β-decay, emission of γ-rays, emission of x-rays, etc.[6-8]. The low energy radiations or weak radiation that do not have enough energy to liberate electrons from an atom thereby leaving the atom charged is known as non-ionizing radiation[1]. ELF (Extremely Low Frequency); Non-ionizing radiation having a frequency range of 3 Hz to 30 Hz (i.e. wavelength 10^7-10^8m) is ELF radiation[9]. Radio waves (wavelength great than 10m) [10], Microwave waves (wavelength from 0.01 cm to 100cm) corresponding frequency (300 MHz to 300 GHz) is the microwave frequency [10]. Laser is the intense beam of radiations having monochromaticity, directionality, spatial coherence, temporal coherence and brightness[11]. Laser stands for light amplification by stimulated emission of radiation and has a frequency ranging from 1011 to 1017 Hz. Invisible radiations having no sense of vision, near to the red end of electromagnetic

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Received: 27 Oct 2021; First Review: 05 Dec 2021; Second Review: 22 May 2022; Accepted: 27 May 2022.
Doi: https://doi.org/10.3126/sw.v15i15.45664

radiation with wavelength extending up to 400,000 Å, is called infrared radiation[12]. Electromagnetic radiation constituting 400 nm (violet) to 700 nm (red) wavelength portion of the electromagnetic spectrum is known as the visible spectrum10. Similarly, the spectrum at the violet end of the visible region having a wavelength ranging from 100 Å to 4000 Å is known as the ultraviolet spectrum [12].

A literature search reveals that the background radiation level within Darchula district, Nepal, has not been reported yet. So, the main aim of this study is to measure the background radiation level and analyze its variation at the different places within the district. Also, we have compared the level of background radiation measured in this study with the levels of radiation in Kanchanpur district, Nepal, measured earlier[13]. Shah et al monitored a survey on radiation exposure at the Shivalik range as well through the East-West Mahendra highway and found a maximum radiation exposure rate of up to 1mr/h at Tinbhangale, Makawanpur 14. Gautam et al studied the annual dose from the background radiation in Pokhara, Nepal, and found it to be within the secure limit of the normal background recommended by the International Commission on Radiological Protection (ICRP) (1 mSv/yr) 15. Nishad et al analyzed proteomics based on multiplexed isobaric tags (iTRAQ) coupled with LC–MS on human peripheral blood mononuclear cells from HLNRA individuals, in Kerala, India, and found low recovery and adaption to the low dose radiation [16].

Materials and methodology

Working site

Darchula is one of the remote and hilly districts that lies to the northwest corner of Sudurpaschim Province, Nepal. This district is surrounded by India and China. To the west, there is the Pithoragarh district of Uttarakhand state, India and Tibet, China to north. Bajhang and Baitadi lie to the east and south, respectively. Geographically, Darchula lies between 28°31' to 30°12' N latitude and 80°04' to 81°45' E longitude [14]. This district covers an area of about 2,322 km2 and has an elevation of 940 m from sea level. The altitude of Sudurpaschim province varies from 176 to 7132 m above sea level, and it covers an area of 19539 sq. km 13. In this study, we have chosen nine sample places randomly within the district and collected data from Baishak to Mangsir, 2075, using a simple portable Geiger-Müller counter.

We have taken data, at three to five different places, within the sample places, along all the six directions, and then finally taken their average value for further analysis. The main sample places are; Khalagga (Mahakali Municipality-4; 80.55°E, 29.84°N and about 1033 m), Gokuleshwar (Shaileshikhar) Municipality-9; 80.77°E, 30.03°N and about 2582 m), Byans (Byans Rural Municipality- X; 80°32'34"E, 29□50'54.6"N and about 2734 m), Dattu (Mahakali Municipality-8; 80□25'38"E, 29°47'33" N), Duhun (Duhun Rural Municipality- 4; 80°37'30" E, 29°52'30"N), Latinath (Marma Rural Municipality-2; 80.84°E, 29.84°N and about 3270m), Dallekh (Naugadh Rural Municipality-2) and Satan/Sitola (Apihimal Rural Municipality-6).

i. Geiger-Müller counter

There are many detectors to measure radiations like: Geiger-Müller (GM) counter, semiconductor counter, proportional counter, scintillation counter, Cerenkov counter, spark chamber, diffusion cloud chamber, bubble chamber, Wilson cloud chamber, ionization chamber, solid-state detector, etc. Among these, the GM counter is a common one that works with the ionization produced in its chamber due to the charged particles [11]. GM tube, used in GM counter, is a sensor filled with an inert gas and halogens (in addition) that temporarily conducts electricity when a particle or photon of radiation makes the gas conductive.The counter used in this study was designed and manufactured by "Industrial Equipment & Control (IEC) Pvt. Ltd., Melbourne, Australia". This counter consists of a sealed glass tube enclosing a coaxial metal cylinder serving as a cathode. A thin metal wire is stretched along the axis of the cylinder and serves as an anode. The free end of the metal wire is covered with glass beads such that the corona discharge (an electrical discharge accompanied by ionization of surrounding air) building up at a sharp point is prevented. It also consists of a thin mica (or other materials) window to count even less penetrating radiation like α,β

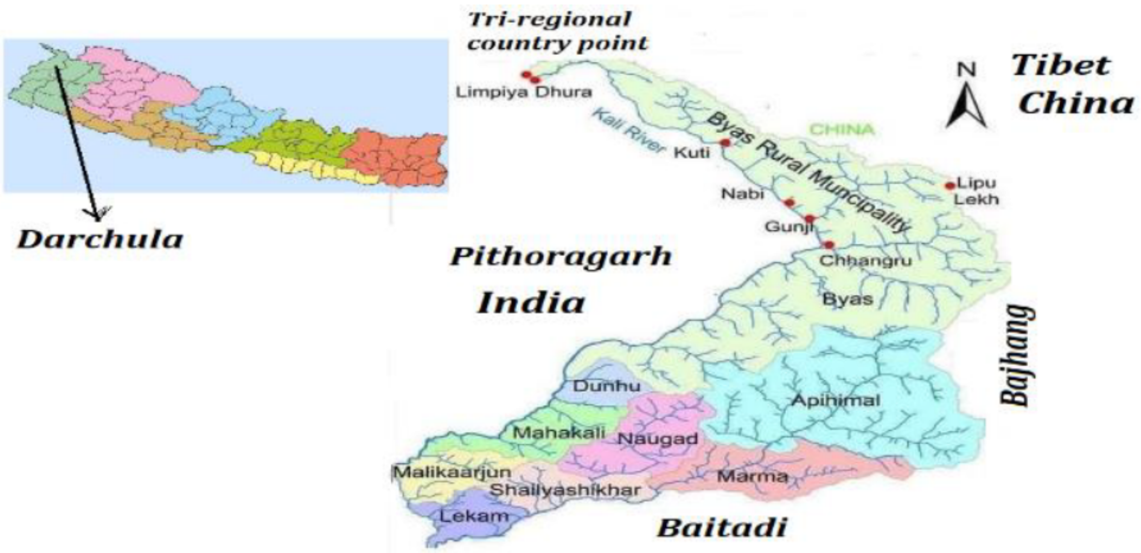


Figure 1: Working site (Google map of Darchula district).

Figure 2: (a) IEC Geiger counter, (b) GM tube and (c) Data collection with the device at Sitola hill.

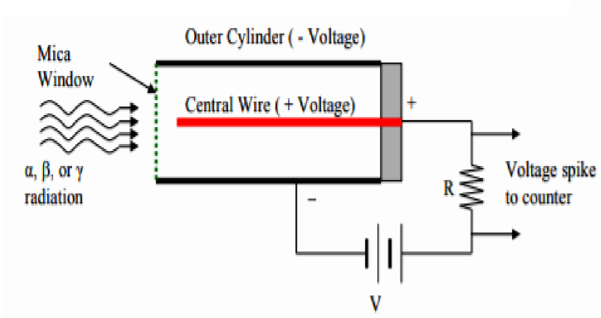


Figure 3: Schematic diagram of a GM counter (source google).

rays, which accounts for the versatility of the GM counter. A sufficiently large potential difference is applied between the wire (anode) and metal cylinder (cathode).

So, applied potential difference accelerates the electron-ion pairs induced by incoming ionizing radiations thus producing an avalanche of electrons reaching to anode and positive ions reaching to the cathode.

ii. Working mechanism of GM counter

Basically, GM counter works under the principle that "the incoming charged particles ionize the gas through which they pass and the electrons so produced during ionization get accelerated by the potential applied between cathode and anode, and further produce ionization". The background radiation entering into the GM tube, containing an inert gas, causes ionization in it. Due to collision, generated electrons get retarded and produce an avalanche of charged particles in two ways: one due to direct interaction between accelerated electrons and gaseous molecules and the second by ultraviolet rays which get generated during the collision. Thus the electron avalanche produced in this way reaches to anode wire and is detected as an electric pulse [15].

Before measuring the level of background radiation, the counter device is set at its own operating voltage. The operating voltage is obtained with the help of a plateau curve by using the formula:

$$V_{OP} = V_1 + \frac{1}{3}(V_2 - V_1),$$

Where V_{op} is the operating voltage, V_1 is Geiger threshold voltage and V_2 is Geiger breakdown voltage.

iii. Method of data collection

The data used was collected by the direct field visit method. A portable GM counter was used to measure the level of background counts.

The background radiation level at the sample places was measured along with six different directions (east, west, north, south, up, and down). Along each direction, the measurement was taken five times, 100 seconds each, and then averaged in the CPM units. The obtained average counts corresponding to each direction were all together, averaged thereby getting a single average count for a place. The average count rate was carried for further analysis. Finally, the average data value was analyzed using a personal computer system available at the computational laboratory, Siddhanath Science Campus.

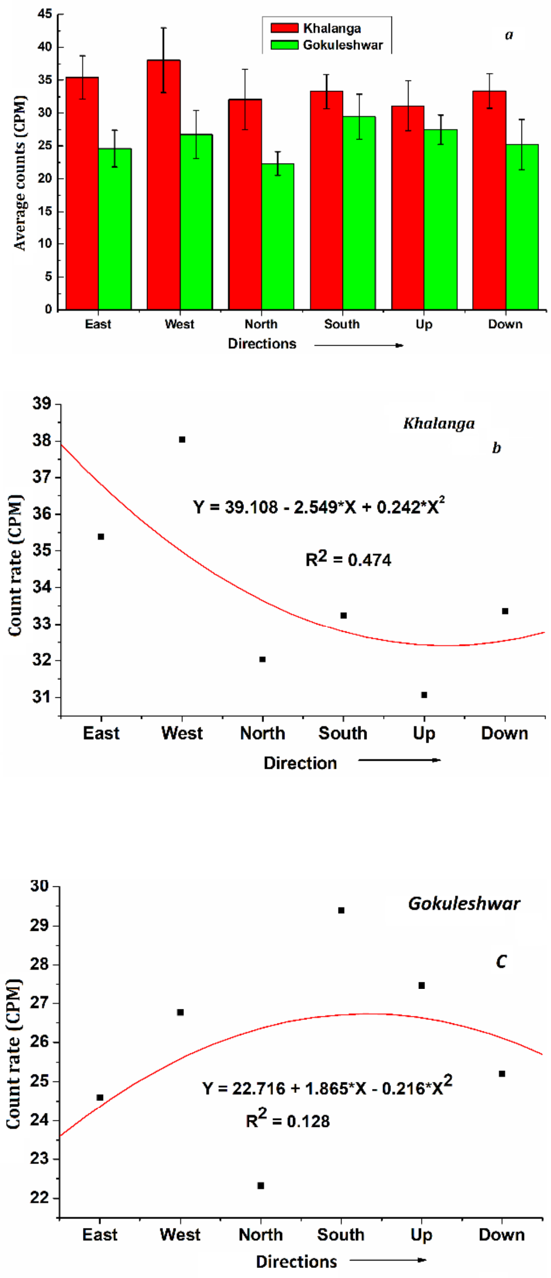
Results and discussion

The background radiation level was measured at different places with the help of a portable GM counter. The averaged data along the six different directions of some sample places within the district has been discussed below:

Table 1. The observed background counts of Khalanga and Gokuleshwar.

Directions	Range of count per minute (CPM) i.e. (min-max)	Average count per 100 sec ± SD	Average count per minute (CPM)	Overall count rate (CPM) ± SD
Khalanga				
East	31.8 - 39.6	59 ± 5.48	35.4	33.86 ± 2.29
West	32.4 - 46.2	63.4 ± 8.19	38.04	
North	26.4 - 37.8	53.4 ± 7.61	32.04	
South	30.0 - 38.44	55.4 ± 4.27	33.24	
Up	26.4 - 36.0	51.8 ± 6.34	31.08	
Down	31.2 - 36.6	55.6 ± 4.41	33.36	
Gokuleshwar				
East	19.8 - 27.6	41 ± 4.60	24.6	25.96 ± 2.30
West	22.8 – 33	44.6 ± 6.09	26.76	
North	19.2 - 24.6	37.2 ± 2.99	22.32	
South	24.6 - 34.2	49 ± 5.76	29.4	
Up	24.6 - 30.6	45.8 ± 3.71	27.48	
Down	22.2 - 32.4	42 ± 6.36	25.20	

A comparison of the observed count rates of some of the places within the district is as given below:



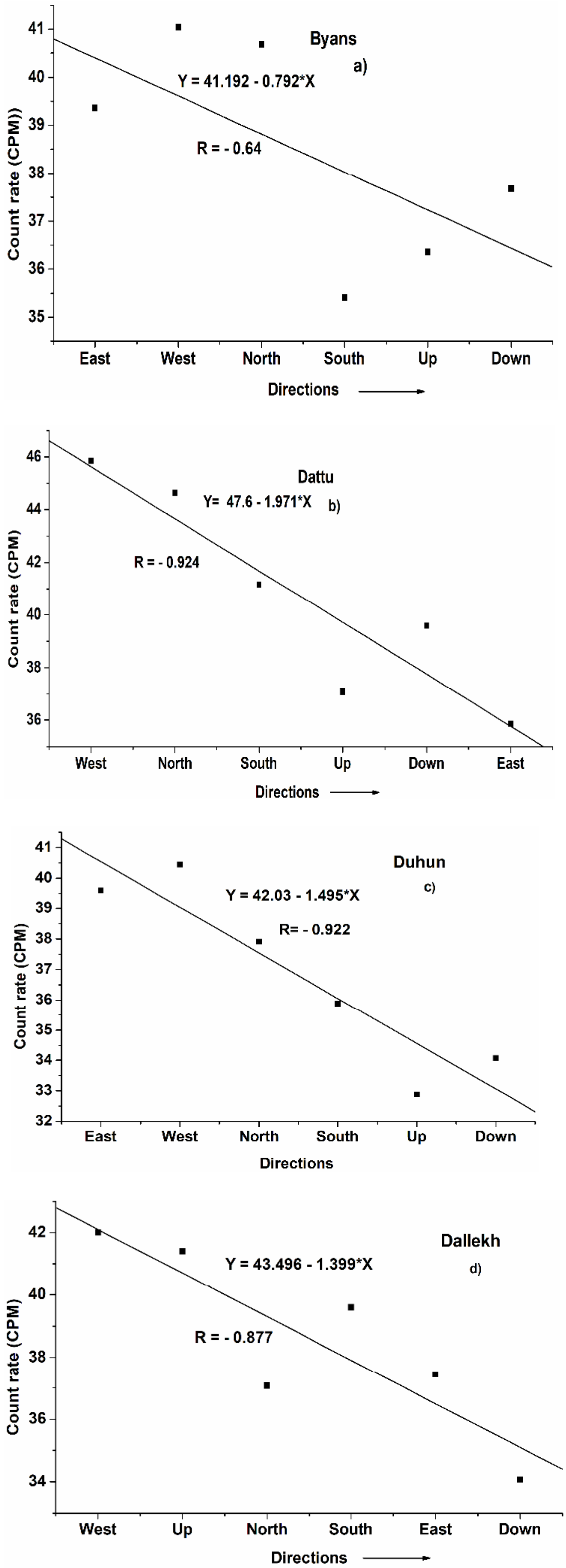


Figure 4: (a) Bar diagram of the observed background radiation level at Khalanga and Gokuleshwar (the error bar shows standard deviation), the polynomial plots of data at (b) Khalanga, and (c) Gokuleshwar.

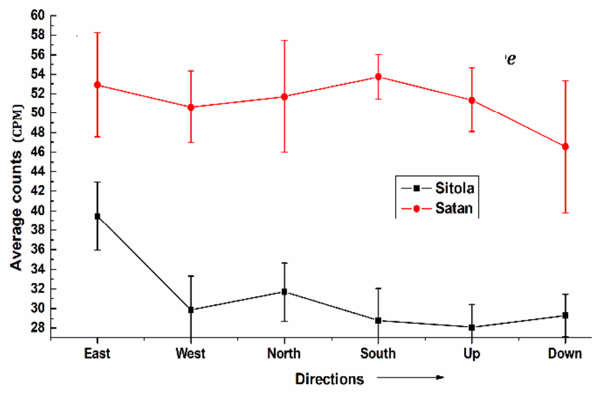


Figure 5: Best fits of the background data recorded at (a) Byans, (b) Dattu, (c) Duhun, (d) Dallekh, and (e) linear (curve) plot of the background data recorded at Satan and Sitola (the error bar shows standard deviation).

For background counts measured per 100 seconds along six different directions of Latinath (one of the remote areas) with the corresponding standard deviations and average count per minute are listed in Table 2. A best fit for data observed at Latinath (with standard deviation value 1.99) is shown in Figure 6.

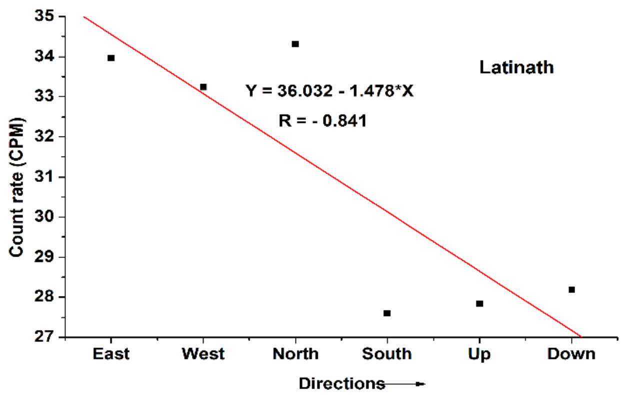


Figure 6: Best fit of the background radiation data recorded at Latinath.

Almost, all the background counts per minute (CPM) were found to vary slightly along with different directions of measurement as shown in Figures 5 and 6. The higher intensity of background radiation indicates the presence of radiation sources to some extent. Particularly, downward background counts could be due to the radiations emitted from radioactive soil, basement rocks, and the materials used like; fertilizers, concrete (cemented) ground, etc. Upward counts could be due to the radiations emanating from outer space what we call cosmic rays. Both the average maximum and minimum counts of rural areas (max: 51.16 $\pm$ 2.30 and min: 30.36 $\pm$ 2.14 CPM) were found to be relatively higher than those of urban areas (max: 33.86 $\pm$ 2.29 and min: 25.96 $\pm$ 2.30). The higher value of the counts at rural places is due to large rocks (as the source of radiations) at relatively higher altitudes. Similarly, the polynomial corves of background count data show a small variation pattern at different places.

The higher value of radiation in Satan is due to the presence of terrestrial sources of radiation in high concentrations. Satan is situated at the highest altitude (more than 3270 meters) with respect to other places thus the higher value could be encountering high cosmic rays. Satan is nearer to the most abundant range of secondary cosmic rays (altitude of 8 -19 km) in comparison to the other places. The maximum mean radiation count in the Darchula district (51.16 CPM) was found to be higher than that in the Kanchanpur district (33.93 CPM). Darchula district extends up to a height of 7132 meters while the Kanchanpur district extends only up to 1528 meters. The higher altitude of Darchula could be a predominant reason for its higher radiation exposure. Normally, the higher the altitude of a place, the higher is its radiation exposure.

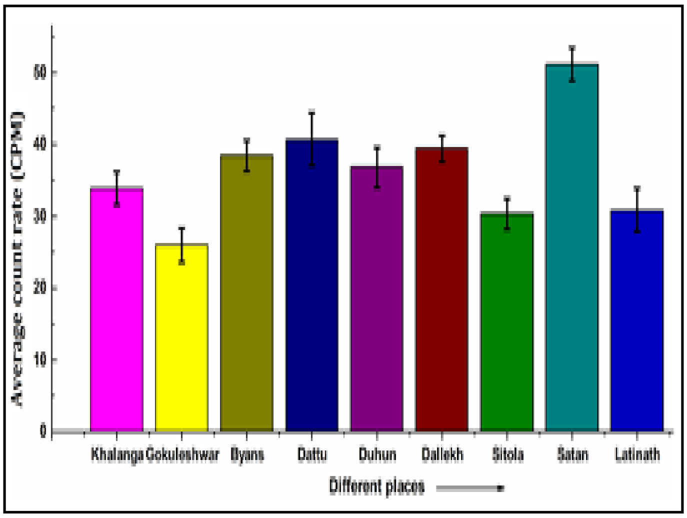


Figure 7: A comparison of observed average counts in different places (error bar shows the standard deviation

Table 2. The observed background counts of Latinath.

Directions	Range of count per minute (CPM) i.e. (min-max)	Average count per 100 sec ± SD	Average count per minute (CPM)	Overall count rate (CPM)± SD
East	30.6 - 37.8	56.6±4.32	33.96	30.86 ± 3.00
West	24.6 – 39	55.4 ± 8.16	33.24	
North	29.4 - 39.6	57.2 ± 6.24	34.32	
South	22.8 – 33	46 ± 6.29	27.60	
Up	24 - 30.6	46.4 ± 4.18	27.84	
Down	24.6 – 33	47 ± 5.22	28.20	

Conclusion

In this work, the level of background radiation within the Darchula district has been measured. The rural areas were found to be exposed to higher background radiation relative to the urban area. However, the fluctuation of background radiation levels between the urban and rural areas is not so significant. In Darchula, the maximum and minimum mean background counts were found to be 51.16 CPM in Satan and 25.96 CPM in Gokuleshwar, respectively. The overall mean background count within the district was found to be 36.39 CPM. The maximum observed count value in Darchula is more than that in Kanchanpur (33.93 CPM). The radiation level of 100 CPM is considered to be the warning level for life. Thus, from this study, it can be concluded that the Darchula district is safe from the radiation level.

Acknowledgments

The authors sincerely thank Prof. Raju Khanal, Central Department of Physics, TU, for his fruitful suggestions and Mr. Ram Nath, an employee at the Department of Physics, Siddhanath Science Campus for his cooperation.

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