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Study of Natural Background Radiation in Bagmati Province, Nepal

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ABSTRACT

In this research, we explored the influence of natural sources on ambient radiation levels in the surrounding environment. Our investigation involved conducting a comprehensive survey of background radiation across seven districts in the Bagmati province. We utilized a Radalert 100 radiation monitor to measure the background dose rate at 141 different locations. The recorded background ionizing radiation at these sites varied from 0.022 mR/hr to 0.028 mR/hr, averaging at 0.025 mR/hr. The mean dose rate was determined to 2.129 ± 0.172 mSv/y. Subsequently, the obtained dose rates were used to compute the Annual Effective Dose equivalent (AEDE) for the local population, revealing values ranging from 0.240 mSv/yr to 0.294 mSv/yr, with an average of 0.270 mSv/yr. Significantly, the AEDE values exceeded the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) limit of annual effective dose (0.07 mSv/yr) recommended for the general public. The elevated AEDE levels are likely attributed to the geological characteristics and rock formation in the study area. Despite the higher AEDE, it is important to note that our overall findings suggest no substantial radiological hazard to the public in the study regions.

Keywords: Background radiation, Bagmati province, Annual effective dose.

INTRODUCTION

External radiation from natural sources primarily originates from cosmic radiation originating in outer space and from naturally occurring radioactive materials within the Earth, known as terrestrial radiation. The extent of exposure to external cosmic radiation varies depending on the location, influenced by factors such as the planet's geomagnetic field, elevation, and solar activity. Terrestrial radiation exposure is affected by the concentrations of radioactive potassium and the presence of radioactive elements in natural uranium and thorium. These concentrations can fluctuate, leading to variations in external dose levels [1].

The average person experiences approximately 2.4 millisieverts (mSv) of background radiation per year [1]. This encompasses both internal and external sources of radiation, such as inhaling radon gas- an inherent radioactive gas found in certain homes- and exposure to cosmic rays during air travel. Although high levels of radiation can be detrimental, the background radiation levels encountered by most individuals are typically insufficient to induce significant health effects. While the consequences of low-level radiation are not completely understood, it is established that prolonged exposure to it can be detrimental to living organisms. The measurement of background radiation levels is essential for comprehending the natural radiation exposure of the population. Notably, similar studies have been conducted in various counties, including Jordan [2], Taiwan [3], Istanbul [4], Iran [5], India [6, 7] and Pakistan [8].

The Bagmati province in Nepal presents a significant locale for a study aimed at measuring the background radiation levels, as no prior investigations on natural background radiation have been conducted in this region. However, a recent study has reported on radionuclides found in the sediments [9] and soil [10] of Kathmandu Valley. Situated in the Himalayan mountain range, the region is characterized by ancient crystalline rocks known to harbor radioactive elements. Furthermore, the Bagmati province is densely populated, featuring diverse communities and numerous settlements, underscoring the importance of assessing potential health risks associated with the background radiation levels in the area. Consequently, the objectives of this study are to furnish valuable insights into radiation levels within the region, providing information that can inform public health policies and safeguard the population against unnecessary radiation exposure.

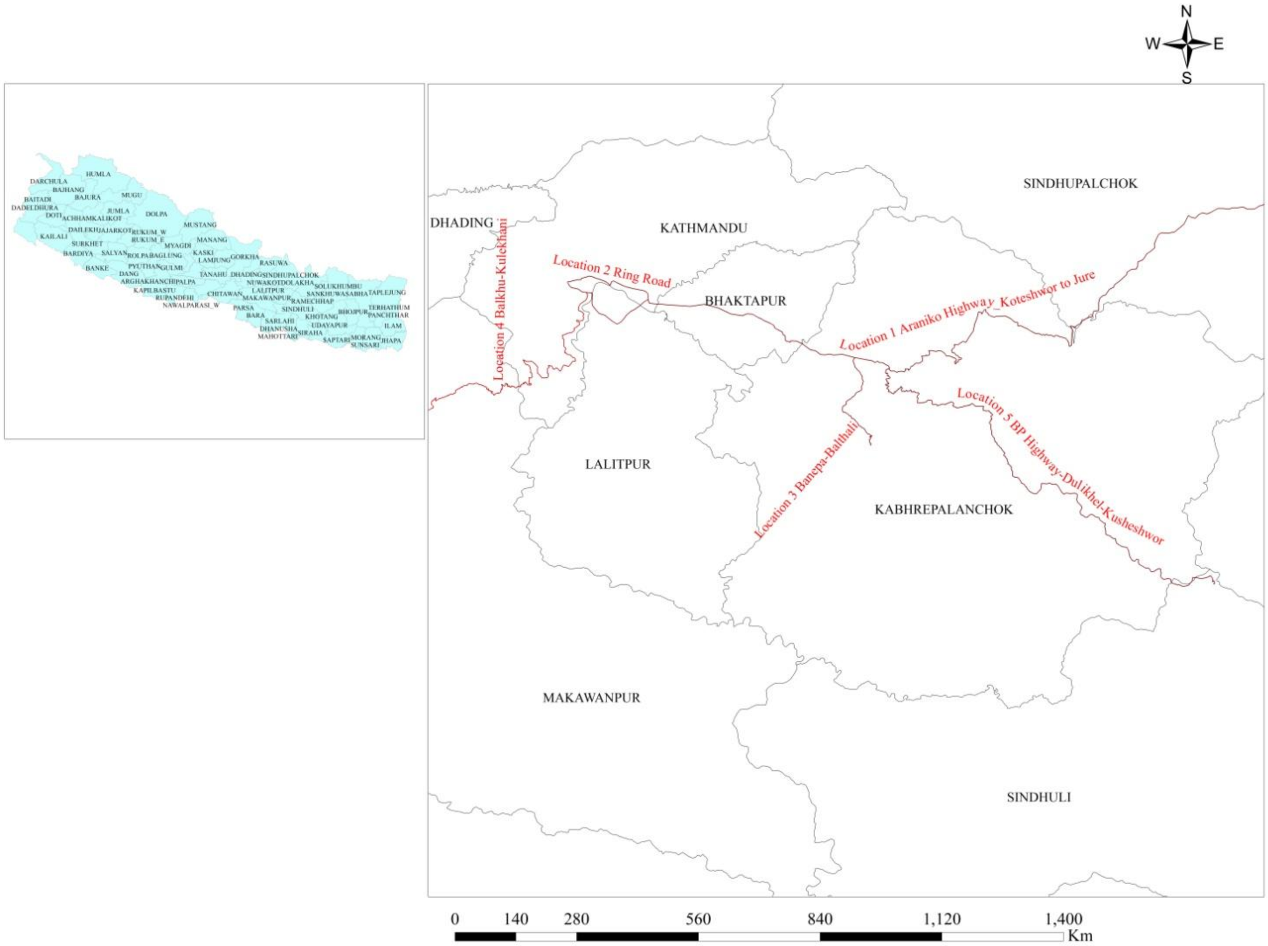

Fig. 1: Representation of locations of Bagmati province.

MATERIALS AND METHODS

The Radalert™ 100 Handheld Nuclear Radiation Monitor having a range of (0.001 to 110) mR/hr was selected as the detector for environmental measurements in this study (Fig. 2). This device is capable of detecting gamma radiation with specific energy levels and has multiple functions such as monitoring personal radiation exposure, monitoring an area or perimeter, detecting radiation leaks and contamination, ensuring regulatory compliance, monitoring changes in background radiation, and checking for radioactive minerals and and displays radiation levels in count rate per minute which was converted in milliroentgen per hour (mR/hr) by relations.

Count rate/minute = 10^{-3} * Quality Factor (For external environments, quality factor is equal to unity)--(1)

Additionally, it has audible and visual alerts to alert users of any potential radiation hazards. The used Radalert 100 in our study was calibrated using Cesium-137 as the standard radionuclide in which calibrations should be done at a certified test range, typically at 660 μSv/hr (66 mR/hr), two-thirds of the maximum reading. Furthermore, prior to conducting the environmental measurements, this device was also calibrated for gamma rays by the Secondary Standard Dosimetry Laboratory (SSDL) to ensure accurate results before doing surveys.

Fig. 2: The device used for radiation dose data collection Radalert 100.

Actually, covering seven districts of Bagmati province background ionizing radiation data were collected in the duration of one month January to February (2023 A.D) from five different locations including Arniko highway covering three district (Bhaktapur, Kavrepalanchowk, Sindhupalchok), Kathmandu and Lalitpur, Makawanpur, and BP highway also known as the Banepa Bardibas highway which also cover two district (Sindhuli and Kavreplanchowk). A total of almost 140 data were collected, with stations selected within a range of 2000m for each location, scaling the Radalert 100 detector on a frame 1m above the ground level. Measurements were taken until the beef sound that is setup in the device, this procedure is repeated in each station because it is not feasible to place the Radalert 100 detector at a single point for an extended period of time. So, the dose measurement in this report is direct observation.

To get more insight on it, the equivalent dose rate was calculated by using the relation [11].

1mR/hr = 0.96*24*365/100 mSv/yr -------------- (2)

Furthermore, the absorbed dose rate was obtained from below conversion factor [12] defined by equation (3).

1mR/hr= 8.7 nGy/hr ---------------------------------- (3)

Moreover, using the dose conversion factor of 0.7 Sv/Gy recommended by UNSCEAR from the absorbed dose in the air to the effective dose and occupancy factor of 0.2 for outdoor [13] which was taken conducting survey too interviewing the people of study area, the annual effective dose equivalent (AEDE) [14] was calculated using following equation (4).

AEDE (mSv/yr) = Absorbed dose (nGy/hr) * 8760 hr * 0.7 Sv/Gy * occupancy factor------------------ (4)

Finally, computing the value of (AEDE), the excess lifetime cancer risk (ELCR) [14] hazard index is calculated using equation (5) in which average duration of life in context of Nepal is taken 66.2 years [15] and risk factor of $5*10^{-2}$ Sv^{-1} was taken recommended by the ICRP for stochastic effects [16].

Excess lifetime cancer risk (ELCR) = AEDE* Average duration of life *Risk Factor-------------- (5)

RESULTS AND DISCUSSION

The background ionizing radiation (BIR) exposure rate in each data collected stations/locations within a range of 2000m covering seven districts of Bagmati province are represented in Figure 3. Also their comparative mean with corresponding standard deviation over the number of radiological data are listed in table 1.

In this study, detected background ionizing radiation for the different stations/locations was differ from place to places. Each dose were around the average dose which shows the fine distributions of dose at every locations. In Arniko highway, the average background ionizing radiation is about 0.022 mR/hr within the range of 0.029-0.014 (mR/hr) as shown in figure 2. Also in overall Kathmandu and Lalitpur districts, the average background ionizing radiation measured (0.025 ± 0.005) mR/hr. But Kavrepalanchowk district has higher value of background radiation dose than that of other districts which is 0.028 mR/hr within the range of (0.041-0.018) mR/hr. The average value of background ionizing radiation measured in all district seems more than worldwide average i.e. 0.013 mR/hr [12, 15, 16] as shown in figure 3. The overall average background ionizing radiation of Bagmati Province is (0.025 ± 0.002) mR/hr which is around 1.9 times higher than recommended limit. This is because of geological formations of all districts with big rocky mountains containing some naturally occurring radionuclides. Also the average background ionizing radiation of Bagmati province of Nepal is higher than reported BIR of three states of Nigeria as shown in table 2.

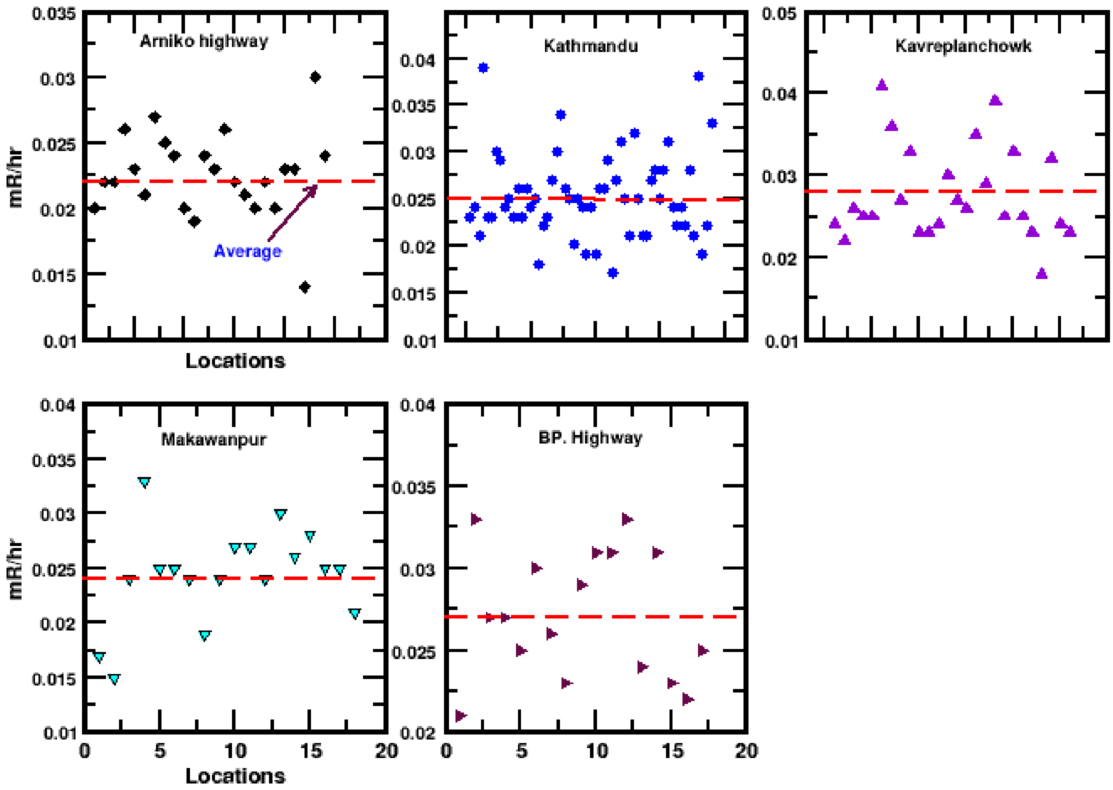

Fig. 3: Background ionizing radiation of different five places covering seven districts of Bagmati province.

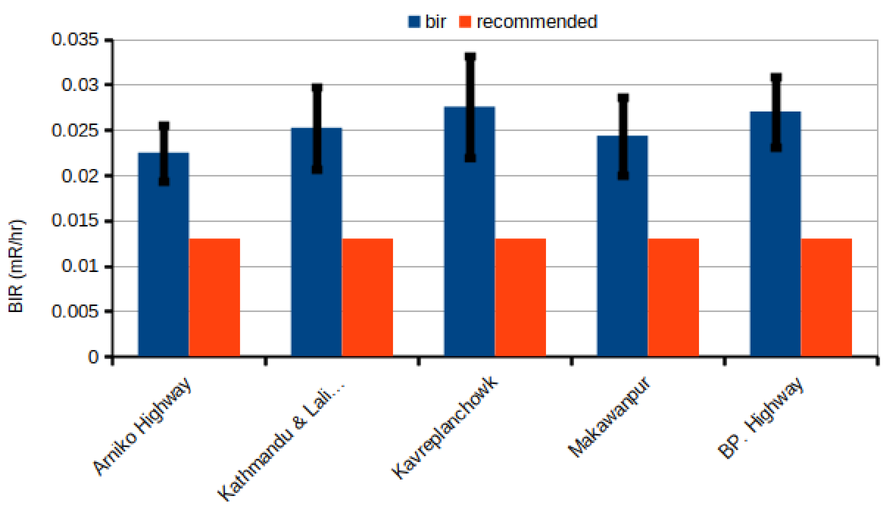

Fig. 4: Background ionizing radiation (bir) with recommended limit at different places.

After getting higher value of BIR in all districts, the hazard indices were calculated as listed in table 1. The equivalent dose rate of Bagmati province was calculated by using equation (2) and ranged from 1.890 to 2.318 mSv/yr with overall mean dose rate (2.129 ± 0.172) mSv/yr, which was higher than the recommended limit i.e 1 mSv/yr. Further for more accountability, the absorbed dose rate was calculated which shows the obtained value is 3.7 times than the worldwide average i.e 59.0 nGy/hr [14]. Moreover, calculated average annual effective dose equivalent of Bagmati province from table 1 shows heavily radiological contaminated geological formation. Also AEDE in each places is found to be equally distributed around Bagmati province of Nepal.

Table 1: Measured background ionizing radiation and estimated hazard indices of different places.

Places	Average background ionization radiation (mR/hr)	Equivalent dose rate ($mSvy^{-1}$)	Absorbed dose rate ($nGyh^{-1}$)	Annual effective dose equivalent ($mSvy^{-1}$)	Excess lifetime cancer risk (10^{-3})
Arniko Highway	0.022 ± 0.003	1.890	195.58	0.240	0.794
Kathmandu and Lalitpur	0.025 ± 0.005	2.121	219.466	0.269	0.891
Kavreplanchowk	0.028 ± 0.006	2.318	239.755	0.294	0.973
Makawanpur	0.024 ± 0.004	2.048	211.840	0.260	0.860
BP. Highway	0.027 ± 0.004	2.269	234.725	0.288	0.953
Average	0.025 ± 0.002	2.129 ± 0.172	220.273±17.819	0.270 ± 0.022	0.894 ± 0.072

Finally, assessing the calculated hazard indices the mean excessive lifetime cancer risk is found to be 0.794, 0.891, 0.973, 0.860 and 0.953 for Arniko highway, Kathmandu and Lalitpur, Kavreplanchowk, Makawanpur and BP. Highway respectively with overall average value of 0.894 for Bagmati Province of Nepal which is almost 3 times higher than worldwide limit value as listed in table 2. The comparison with three states of Nigeria with our work is shown in Table 2.

Table 2: Comparison of background ionizing radiation and estimated hazard indices of Bagmati Province, Nepal with different state of Nigeria.

	Our work	Delta state, Nigeria [14]	Enugu State, Nigeria [17]	Ebonyi State, Nigeria [18]	Recommended Limit [14]
BIR (mR/hr)	0.025	0.016	0.016	0.0145	0.013 [17, 18]
Indices					
EDR (mSv/yr)	2.129	1.37	1.15	----	1.00
ADR (nGy/hr)	220.273	141.30	-----	128.325	59.0
AEDE (mSv/yr)	0.270	0.17	-----	0.15	0.07
ELCR $*10^{-3}$	0.894	0.61	-----	0.550	0.29

CONCLUSION

In this framework, radiation dose were measured in five different places covering seven district of Bagmati province. The measured result showed Kavrepalanchowk has the maximum background radiation dose than that of other four places. Also we found the dose around the seven district of Bagmati province is more than that of worldwide average. It is because of the geology structure and the formations of rocks found in these places. Our findings shed light on the current levels of background radiation in these areas, which can inform future efforts to mitigate radiation exposure risks. Also the overall study shows there is no radiological hazard to public.

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