

Annual Effective Dose from Natural Background Radiation in Pokhara, Nepal

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Authors' contributions

This work is conducted under the guidance of author BA with group efforts of all authors at all stages. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJR2P/2020/v3i230119

Editor(s):

(1) Prof. Shi-Hai Dong, National Polytechnic Institute, Mexico.

Reviewers:

(1) Shrabani Basu, Siksha 'O' Anusandhan (Deemed to be University), India.

(2) Lanunola Tzudir, Nagaland University, India.

(3) Khaled Mohammed Haroun, Al-Zaiem Al-Azhari University, Sudan.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/58650>

Original Research Article

Received 02 May 2020

Accepted 08 July 2020

Published 18 July 2020

ABSTRACT

Measurement of outdoor natural background radiation doses at different locations of Pokhara city, Nepal was carried out using GCA-07W, Nuclear Regulatory Commission (NRC) certified Geiger Muller (GM) detector. From the measurements, the least value of background radiation dose rate was found to be $0.26 \pm 0.08 \mu\text{Sv/hr}$ for Mahendra Cave area, and the highest value of dose rate was found to be $0.65 \pm 0.12 \mu\text{Sv/hr}$ for Prithvi Narayan Campus. The average annual effective dose rate of Pokhara city was found to be $0.56 \pm 0.12 \text{ mSv/yr}$ ranging from $0.31 \pm 0.09 \text{ mSv/yr}$ to $0.80 \pm 0.14 \text{ mSv/yr}$. The radiation levels in Pokhara, the most populated city of the western development region of Nepal, were found to be within the secure limit for areas of the normal background recommended by the International Commission on Radiological Protection (ICRP) (1 mSv/yr). Further, the current result was compared with the previous study of annual effective dose rate measured in Kathmandu city. Comparable value of the average annual effective dose rate in Pokhara and Kathmandu was obtained.

Keywords: Background radiation; effective dose; safety limit; health hazard; Pokhara.

1. INTRODUCTION

In the environment, natural radioactivity is existing from the time of origination of the universe. Human beings have been compulsorily exposed to ionizing radiations of natural origin at every location. Ionization radiation cause changes in the chemical state of material by affecting them which are biologically relevant [1]. Injuries and clinical symptoms such as chromosomal transformation, cancer induction free radical formation, born necrosis, and radiation cataract genesis, can be caused by the exposure to ionizing radiation [2]. For a member of the public, the effective dose due to ionizing radiation varies significantly depending on where they live, occupation, diet, personal habits, building structures, and home utilization patterns [3]. Because we are inescapably exposed to environmental background radiation, radiation monitoring is an essential precaution against overexposure to harmful ionizing radiation.

Background radiation contains cosmic radiation and the radiation emitted from the radioactive substances present in the earth or commercial sources. The source of natural background radiation includes the radionuclides ^{238}U , ^{232}Th , ^{40}K , ^{222}Rn , and ^{220}Rn present in the indoor and outdoor surroundings. Geology and graphical characteristics of the place and human activities are the dependent factors of the distribution and ability of these radionuclides. The leading cause of the variation of the amount of radiation received is due to the location, rock and soil types, type of building materials, etc. [4]. According to International Atomic Energy Agency (IAEA), dose contribution to the environment shows that a human received 85% background radiation from natural radionuclides, and the remaining 15% is from cosmic rays and nuclear process [5].

Some areas have a larger dose rate than the country-wide averages. Globally, exceptionally high natural background areas include Ramar in Iran, Guarpan in Brazil, Karunagappalli in India, Arkaroola in South Australia, and Yangjiang in China. Maximum outdoor radiation was recorded in Malaysia [6]. The maximum level of natural background radiation ever recorded on the earth's surface was 90 $\mu\text{Gy/h}$ on a Brazilian black beach composed of monazite [7], which is equivalent to 0.8 Gy/yr but the levels are differing seasonally and are much lower in the closest residence. Primarily due to the use of local

naturally radioactive limestone as a budding material, Ramar is discovered to be another location of excessive background radiation. The thousand most exposed residents receive an average external effective radioactive dose of 6 mSv/yr which is 6 times more than the dose limit recommended by the International Commission on Radiological Protection (ICRP) for exposure to the public from artificial sources. Additionally, they receive a substantial internal dose from radon, record radiation levels were found in a house where the effective dose due to ambient radiation field was 131 mSv/yr, and the internal committed dose from radon was 72mSv/yr. This unique case in Ramar is over 80 times more than the world average natural human exposure to radiation [8,9]. Radiation measurement was performed in Maharashtra (South Konkan), India. In the air, the average absorbed dose rate was estimated as 66.89 nGy/hr. The effective dose rates per annum were found to lie in the range 0.27 mSv/yr to 0.85 mSv/yr with an annual effective dose rate of 0.49 mSv/yr. The mean radium equivalent activity rate for soil samples of South Konkan was 144.84 Bq/kg [10]. Panta et al., 2018 [11] studied the natural background radiation dose in the Kathmandu city of Nepal. The average effective dose rate of Kathmandu Valley was found to be 0.475 mSv/yr varying from 0.391 mSv/yr to 0.661 mSv/yr. They concluded that the natural exposure level at Kathmandu valley is not hazardous to the people in the study regions. Timilsina et al., 2017 [12] studied the radiation count at nine different places of Syangja valley of Nepal using GM counter. They recorded the count rate in counts per minute (cpm) ranging from 21.63 cpm to 49.98 cpm.

The current work aims to study the effective dose from a natural background in Pokhara city of Nepal. The results would provide a baseline upon which other exposures may be assessed and, in the future, serve a reference for dosimetry and decontamination in the case of radiation poisoning in the Pokhara city. The paper is structured as follows. In section II, the material and methods used throughout this paper are introduced. Results and discussion are described in section III. Section IV concludes the work and provides a future perspective.

2. MATERIALS AND METHODS

A new GCA-07W Professional GM Counter (as shown in Fig. 2) was used to measure the



Fig. 1. Map of Pokhara City of Nepal [15,16]

outdoor radiation doses at different locations of Pokhara city. It detects a wide spectrum of nuclear radiation, containing low energy background radiation. It has a 16 x 2 character liquid crystal display (LCD) that shows radioactive count and radiation level in mR/hr or mSv/hr. Counts per Second (cps) or Counts per Minute (cpm) mode can be selected using the time selection switch. It has a counting capacity in the range from 1 cpm to 10,000 cps. It has the ability to detect the ionizing radiations such as Alpha particles above 3 MeV, Beta radiation above 50 KeV, X-ray and Gamma radiation above 7 KeV. Thin mica window embedded in the detector allows alpha radiations to be detected. It has a detecting range 0.001 mR/hr resolution to 1000 mR/hr range (Imperial Measurements) which is equivalent to 0.01 uSv/hr resolution - 10 mSv/hr range (Metric Measurements). Factory calibration using the National Institute of Standards and Technology (NIST) traceable radiation source insures that the tool gives accurate radiation measurements. Also, GCA-07W is an NRC certified tool to measure radiation. NRC certification certifies that our Geiger counter has passed 10-CFR-34 and 10-CFR-35 United States NRC calibration standards [13].

Twenty sample areas (A1, A2...A20) were randomly selected in Pokhara city. Outdoor background radiation readings were taken in open fields using GCA-07 professional GM

counter. Observations were done in twenty different locations of Pokhara valley from 12 January 2018 to 26 January 2018 in between 11 am to 2 pm. To accounts for error in data, sixty different readings were taken in each sample area. The average dose rate and standard deviation for each location were calculated. The device was held at 1 meter above the ground level for the radiation measurements. The map of the sampling area is shown in the Fig. 1.



Fig. 2. GCA-07 GM detector [13]

The annual effective dose rate for outdoor background radiation was computed using the following expression [14],

$$E_o = \eta (mSv/hr) \times 8760 \text{ hrs/yr} \times 0.2 \times 0.7(1)$$

Here, E_o represents the outdoor annual effective dose equivalent (mSv/yr). η is the outdoor meter reading (mSv/hr) = outdoor observed dose rate. 0.2 is the outdoor occupancy factor. 0.7 is the conversion coefficient.

3. RESULTS AND DISCUSSION

Based on the methodology, as mentioned in the previous section, the annual effective dose rate equivalent at different locations of Pokhara city was measured. In Table 1, columns 1, 2, 3, 4, and 5 represent the area code, name of the sampling area, GPS coordinates of the sampling area, observed equivalent dose rate, and the annual effective dose equivalent respectively. The value in the bracket, along with the dose equivalent represents the corresponding standard deviation. Data from Table 1 are presented in graphical forms for straightforward interpretation.

The results listed in Table 1 indicate that the Prithvi Narayan Campus area (A20) was found to have maximum outdoor background radiation. The average dose equivalent at A20 was found to be $0.65 \pm 0.12 \mu\text{Sv/hr}$. Minimum radiation was measured, $0.26 \pm 0.08 \mu\text{Sv/hr}$, at the Mahendra cave area (A1). Fig. 3 represents the average annual effective dose from natural background radiation at twenty different places of Pokhara city. It shows that the annual effective dose rate

at areas A1 to A20 was found to lie within the range $0.31 \pm 0.09 \text{ mSv/yr}$ to $0.80 \pm 0.14 \text{ mSv/yr}$ with the maximum annual effective dose rate, $0.80 \pm 0.14 \text{ mSv/yr}$, at Prithvi Narayan Campus area (A20) and minimum dose rate, $0.31 \pm 0.09 \text{ mSv/yr}$, at Mahendra cave area (A1). The average annual effective dose rate in Pokhara city was found to be $0.56 \pm 0.12 \text{ mSv/yr}$. Fig. 4 represents the comparison of annual effective dose rate measured at Pokhara city with the dose limit set by ICRP (1 mSv/yr) [17] for a member of the public. We found that the average dose rate in Pokhara city was less than the ICRP limit. This indicates that there is no significant radiation hazard due to background radiation around sampling areas of Pokhara city. We were also interested in comparing the radiation levels in different areas such as the hospital area, caves area, at high altitudes (hill regions), and residential area which is shown in Fig. 5. We found an average dose of $0.60 \pm 0.08 \text{ mSv}$ per year at the hospital area, which is found to be comparable to the average dose rate, $0.57 \pm 0.11 \text{ mSv/yr}$ around the residential area. It indicates that the various scientific imaging facilities which might be present in the hospital area, chargeable for emitting radiation are properly handled with care with the aid of the hospital administration. We found the higher dose rate, $0.67 \pm 0.03 \text{ mSv/yr}$, around the places at height, regions having dense vegetation areas, which include KanhuDanda, Peace Stupa, and Lovely hill. Minimum radiation dose, 0.39 ± 0.05 was measured at cave area. Fig. 6 represents

Table 1. Effective dose from natural background radiation at different locations of Pokhara city

Area Code	Name of Area	GPS Coordinates	$\eta(\mu\text{Sv/hr})$	$E_o(\text{mSv/yr})$
A1	Mahendra Cave	28.2719°N, 83.9798°E	0.261 (0.080)	0.312 (0.098)
A2	Seti River	28.2457°N, 83.9800°E	0.321 (0.060)	0.393 (0.073)
A3	Bat Cave	28.2673°N, 83.9760°E	0.338 (0.084)	0.414 (0.103)
A4	Gupteshwor Cave	28.1925°N, 83.9559°E	0.347 (0.085)	0.425 (0.104)
A5	AudhogikKshetra	28.2033°N, 84.0118°E	0.355 (0.086)	0.435 (0.104)
A6	Rambazar	28.2009°N, 83.9962°E	0.399 (0.079)	0.489 (0.096)
A7	SrijanaChowk	28.2117°N, 83.9814°E	0.411 (0.079)	0.504 (0.097)
A8	Bindabashini	28.2378°N, 83.9842°E	0.421 (0.118)	0.516 (0.144)
A9	Pokhara Airport	28.1994°N, 83.9784°E	0.429 (0.077)	0.527 (0.094)
A10	Lamachowr	28.2613°N, 83.9721°E	0.483 (0.098)	0.592 (0.120)
A11	Malepatan	28.2181°N, 83.9731°E	0.484 (0.086)	0.593 (0.105)
A12	Birauta	28.1915°N, 83.9691°E	0.506 (0.117)	0.621 (0.144)
A13	Lovely Hill	28.2222°N, 83.9787°E	0.517 (0.120)	0.634 (0.147)
A14	Manipal Hospital	28.2369°N, 83.9967°E	0.522 (0.113)	0.640 (0.139)
A15	Lakeside	28.2100°N, 83.9558°E	0.566 (0.127)	0.694 (0.155)
A16	Gandaki Hospital	28.2123°N, 83.9974°E	0.530 (0.111)	0.650 (0.136)
A17	Chipledhunga	28.2246°N, 83.9890°E	0.531 (0.113)	0.650 (0.138)
A18	Peace Pagoda	28.2006°N, 83.9459°E	0.551 (0.123)	0.675 (0.151)
A19	KahunDanda	28.2399°N, 84.0076°E	0.580 (0.126)	0.711 (0.155)
A20	PN Campus	28.2400°N, 83.9917°E	0.652 (0.116)	0.799 (0.142)

the comparison of the annual dose rate of Pokhara city with the previous study of the annual dose rate measured in Kathmandu city [11]. It reveals a clear indication of the comparable value of the annual effective dose rate in two main cities of Nepal, viz. Pokhara and Kathmandu.

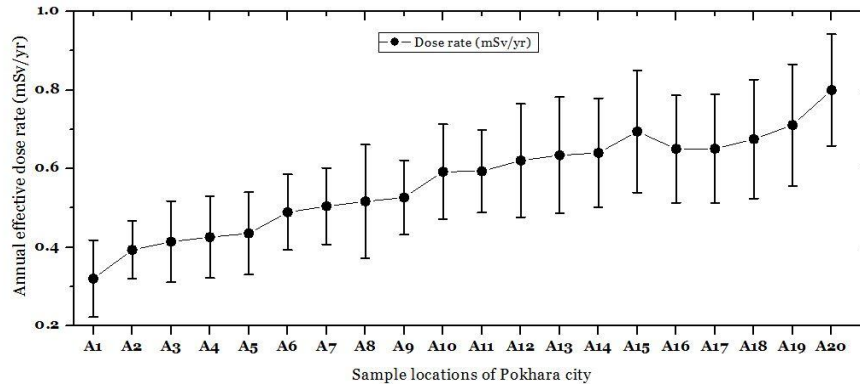


Fig. 3. Annual dose rate equivalents at different places of Pokhara city

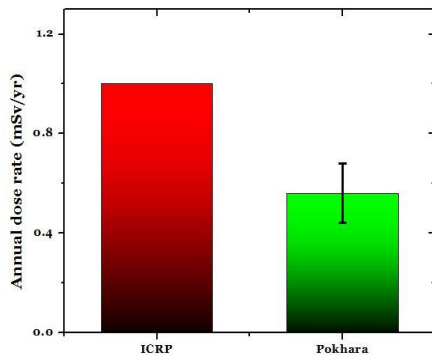


Fig. 4. Comparison of average annual effective dose rate of Pokhara city with ICRP dose limit for a member of the public

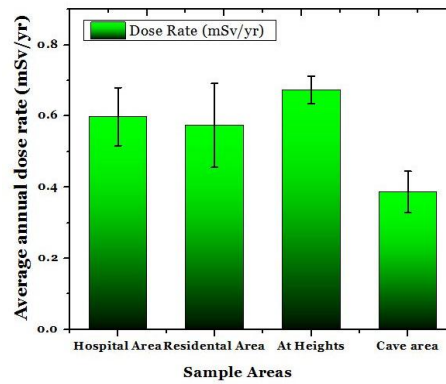


Fig. 5. Comparison of annual effective dose rates in different areas

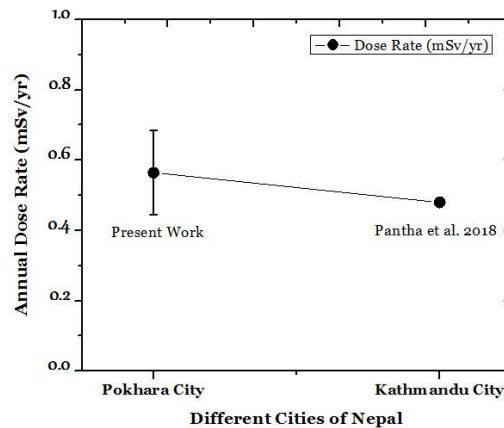


Fig. 6. Comparison of average annual effective dose rate of Pokhara city with Kathmandu city

4. CONCLUSION

Natural background radiation dose at different locations of Pokhara city was studied using GCA-07 professional Geiger Muller Counter. Data were collected from the twenty sampling locations. The average annual effective dose was found to be 0.56 ± 0.12 mSv/yr, ranging from 0.31 ± 0.09 mSv/yr to 0.80 ± 0.14 mSv/yr. We compared our findings with the ICRP dose limit (1 mSv/yr) for a member of the public, and it was found that the average annual effective dose of the mentioned areas of the Pokhara city did not exceed the ICRP limit. Hence, we conclude that the natural exposure level in Pokhara city is not hazardous to the people in the respective regions where the study was conducted. In the comparison of the average annual effective dose rate of Pokhara with the previous study of annual dose rate measured in Kathmandu, we found that the average annual effective dose in Pokhara and Kathmandu is almost the same. These types of work would be beneficial for the government serving references for future solid mineral exploration within the studied locations. For all practical purposes, the outcomes received in this study for the different locations of the Pokhara city offer baseline facts of any pollution in the environment due to any accidental releases of radionuclides. Thus, those findings would serve as a reference for future studies.

ACKNOWLEDGEMENTS

We express our gratitude to the Central Department of Physics, Tribhuvan University, Kirtipur, Nepal for providing the equipment used for this work.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
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