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Real-time Environmental Gamma Dose Monitoring around Dhaka University Campus and Estimation of Excess Lifetime Cancer Risk on Public Health

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Abstract: This study aims to determine the environmental and manufactured radiation dose and evaluation ELCR, which depends on the annual effective dose (total absorbed radiation dose of the whole body during a year). The total dose rate has been monitored around the Dhaka university campus. This study used a digital portable radiation monitoring device for radiation dose measurements and a personal navigator for location identification. During this monitoring, placed a survey meter 1 meter above the ground. The measured dose rate differs from 0.067±0.015 ~ 0.19±0.01 μSv/h with a mean value of 0.138±0.009 μSv/h. The outdoor annual effective dose (AED) for the public varied from 0.117±0.027 ~ 0.333±0.017 mSv/y with a mean of 0.242± 0.016 mSv/y. From this study, the value of AED is less than 1 mSv/y which is the maximum acceptable public exposure limit (ICRP,2007). ELCR on public health was also calculated from these data ranging from 0.48×10^{-3} ~ 1.37×10^{-3} with a mean value of 0.99×10^{-3}

Keywords: Radiation dose, Annual effective dose, ELCR, Gamma scout, Dhaka.

1 Introduction

Environmental radiation has been released from mainly terrestrial and extraterrestrial elements since the earth's formation. Environmental radiation can be divided primarily into: Primordial, Cosmogenic, and Anthropogenic [1]. Throughout the earth's crust and environment, it contains primordial radionuclides [1]. These primordial radionuclides are responsible for natural radioactivity, which originates from the earth's formation and spreads everywhere, including the human body [2]. During the interaction between cosmic radiation and particles in the earth's atmosphere and through dry and wet deposition, cosmic radionuclides can be produced [1, 3]. Anthropogenic radionuclides result from human activities, but it is always considered background radiation [3]. About 13% of the background radiation of humankind comes from various types of anthropogenic radionuclides declared by UNSCEAR [4]. The total amount of radiation present in any specific region of the earth mainly depends on the types and amount of terrestrial material and cosmic rays present in that place. Air, water flow, and other media can spread the radiation. Naturally, it has been seen that where cosmic rays fall for a longer time and terrestrial elements are in a huge amount, the background radiation doses in that type of place are higher than in other places if artificial radiation and any nuclear power plant are not situated on these places. ^{40}K, ^{238}U, ^{232}Th, and their daughter nuclides are mainly responsible for background radiation from the early stage of the earth [5]. Natural /environmental radiation is enhanced by the sources like metal mining and melting, Phosphate industry, coal mining and power production of coal, oil and gas drilling, rare earth and titanium dioxide industries, and application of radium and thorium [6]. Various monitoring devices are used to measure the amount of radiation in any place. Radiation of any site generally means the total gamma dose-measuring of that area. Among existing ionizing radiation, gamma rays have very high penetrating power compared to others. So this radiation can affect the human body more efficiently. Because if anyhow the radiation dose limit exceeds the permitted limit, this can be hazardous for human life. Our body has some radiation naturally because it's made of ^{14}C, ^{40}K, and ^{3}H. Anthropogenic radionuclides like ^{134}Cs, ^{137}Cs, and ^{90}Sr might harm human life. If the permissible limit of radiation exceeds for anyone, it may cause danger to the public. So it is very vital to monitor the environmental radiation dose regularly. Gamma rays and X-rays, which come from higher energy parts of cosmic rays, are ionizing radiation that can detach electrons from any atoms or molecules [6]. If this dose limit exceeds, that may cause any type of chronic disease like cancer. Excessive amounts

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of radiation can break the double helix bond of DNA and cause mutation in the cell.

Dhaka university is Bangladesh's largest educational institution in the center of the Dhaka district. More than 37 thousand students are studying at this university [7]. Inside and around this campus, many central academic and non-academic institutes like Bangladesh University of Engineering and Technology(BUET), Dhaka Medical College Hospital(DMCH) with radiotherapy and radiology facilities, Atomic Energy Centre Dhaka, Bangla academy, Suhrawardy Udyan, Bangladesh National Museum, School, college, library, mosque, temple, police station, university residential hall, market. As Bangladesh is an overpopulated country, if any type of radiation (gamma radiation) splits in any area, this may be a danger because people are not aware of radiation effects.

2 Materials and Methods

2.1 GAMMA SCOUT:

Real-time environmental dose was monitored in the mentioned area using GAMMA SCOUT (model no: 071017), a portable device for measuring radiation dose. Gamma scout is one common type of Geiger counter which can measure the amount of alpha, beta, gamma, and x-ray present in any monitoring point. It is very usable in therapeutic, atomic, mining, metal scrap, and foundry businesses. This device was made in Germany and developed with a Novadur outline. The measured radiation dose rate (µSv/hr) is displayed on its digital display. There's an analog logarithmic bar chart to rapidly visualize the size of the measured dosage rate. The unit encompasses a battery pointer, different unit changes, and real-time measurements rate. The total value shows capacities, programmable logging, and alarm capacities. Progressed abilities incorporate PC information downloaded utilizing a USB cable and an ultra-low current control circuit for extended battery life [8, 9].

2.2 GAMMA SCOUT calibration:

The GAMMA SCOUT was calibrated inbuilt by the producer. The GAMMA SCOUT is calibrated at the Secondary Standard Dosimetry Laboratory (SSDL) at Bangladesh Atomic Energy Commission (BAEC) utilizing standard gamma-ray sources such as ^{137}Cs, ^{60}Co, etc., and X-ray Unit. The SSDL of BAEC has been working since 1991, which is traceable to the Primary Standard Dosimetry Laboratory (PSDL) of National Physical Laboratory (NPL), UK. The SSDL of BAEC has an X-ray Unit (30 kV-225 kV) for radiation-producing types of gear calibration. BAEC's SSDL is executed and kept up, agreeing to the International Atomic Energy Agency (IAEA)/World Health Organization (WHO). The GAMMA SCOUT accurately determines the measurement rate within the value of 0.01-5000 µSv/hr (User Manual- GAMMA SCOUT, 2014) [9].

2.3 Global positioning system (GPS):

In this study Global Positioning System (Model: 010-00970-00, Garmin eTrex@ 10) has been used. Because of its characteristics like monochromatic display, which is easy to read in every type of light, faster positioning for GPS and GLONASS, paperless geocaching, worldwide map data, and long battery life with 2AA batteries [10]. This device is beneficial for these types of studies.

2.4 Site details:

Figure 1: GPS location of the monitoring points

All the monitoring points were located with GPS (Garmin eTrex@10) device. The study sites are located between 23°44.045' N to 23°44.231' N and 090°23.06´ E to 090°23.928' E. Outdoor environmental gamma dose was measured in and around the Dhaka university campus area, which situates in both Shahbag and New market zone. This monitoring area is one of the populated areas with school, college, university, library, hospital, police station, mosque, temple, market, and office. This surveillance benefits the safety of all people who live and work in this area.

2.5 Data collection and dose calculation:

The study was performed from August to October 2021. For dose measurement, digital Gamma Scout was set at 1 m (gonad height) above the ground level, kept in that position for 1h in each monitoring point, and confirmed location latitude/ longitude with GPS.

By the recommendation of UNSCEAR 1988, the outdoor occupancy factor (OF) is 0.2 for the public [11]. The occupancy factor is the ratio of time spent by a person in a specific region. The formula for determining the annual effective dose is given below:

Annual effective dose = Dose rate (µSv/h) × OF (0.2) × Total time (8760 h/yr) (1)

The formula to calculate the excess lifetime cancer risk (ELCR) factor is:

ELCR= AED × *DL* × RF (2)

Where, AED is the annual effective dose, DL is the duration of life for the public of Bangladesh [12], and RF is the fatal cancer risk factor. From the recommendation ICRP 103, the risk factor for the low dose radiation stochastic effects is 0.057 for common people (ICRP, 2007).

3 Results

3.1 Absorbed dose rate and annual effective dose:

Table 01: Outdoor environmental dose rate and annual effective dose with estimated lifetime cancer risk (ELCR) for 61 monitoring points in and around Dhaka university campus.

Points No.	Location	GPS coordinates	Dose Rate range (µSv/h)	Mean Gamma Dose Rate (µSv/h)	Annual Effective Dose (mSv/y)	ELCR ($\times10^{-3}$)
01.	Engineering University School and College	23° 43.682′ N 090°23.601′ E	0.125-0.150	0.138±0.013	0.241±0.022	0.99
02.	Palashi Market	23°43.653′ N 090°23.366′ E	0.135-0.148	0.142±0.007	0.248±0.011	1.02
03.	Nilkhet	23°43.950′ N 090°23.111′ E	0.145-0.183	0.163±0.019	0.286±0.033	1.18
04.	Bangladesh Telecommunication Companiy Limited Residential	23°43.93′ N 090°23.06′ E	0.121-0.145	0.133±0.012	0.232±0.021	0.96
05.	Teacher Student Centre (TSC)	23°43.926' N 090°23.719' E	0.138-0.144	0.141±0.003	0.246±0.005	1.02
06.	Suhrawardy Udyan	23°44.009' N 090°23.811' E	0.131-0.137	0.134±0.003	0.235±0.005	0.97
07.	Ramna Kali Mandir	23°43.866' N 090°23.928' E	0.102-0.117	0.108±0.008	0.190±0.014	0.78
08.	TSC 2	23°43.939' N 090°23.717' E	0.14-0.16	0.15±0.01	0.263±0.017	1.083
09.	TSC 3	23°43.975' N 090°23.726' E	0.06-0.08	0.07±0.01	0.123±0.017	0.505
10.	Dhaka University (DU) Library	23°43.051' N 090°23.723' E	0.12-0.14	0.13±0.01	0.228±0.017	0.939
11.	Kazi Nazrul Islam's Graveyard	23°44.107' N 090°23.717' E	0.10-0.12	0.11±0.01	0.193±0.017	0.794
12.	Fine Arts	23°44.167' N 090°23.722' E	0.14-0.16	0.15±0.01	0.263±0.017	1.083
13.	Public Library	23°44.217' N 090°23.724' E	0.17-0.19	0.18±0.01	0.315±0.017	1.299
14.	National Museum	23°44.231' N 090°23.730' E	0.12-0.14	0.13±0.01	0.228±0.017	0.939
15.	Shahbag Thana	23°44.221' N 090°23.748' E	0.10-0.12	0.11±0.01	0.193±0.017	0.794
16.	Suhrawardy Udyan 2	23°44.179' N 090°23.742' E	0.10-0.12	0.11±0.01	0.193±0.017	0.794
17.	Suhrawardy Udyan 3	23°44.136' N 090°23.743' E	0.12-0.14	0.13±0.01	0.228±0.017	0.938
18.	Suhrawardy Udyan 4	23°44.112' N 090°23.779' E	0.14-0.16	0.15±0.01	0.263±0.017	1.083
19.	Suhrawardy Udyan 5	23°44.083' N 090°23.775' E	0.12-0.14	0.13±0.01	0.228±0.017	0.938
20.	Suhrawardy Udyan 6	23°44.045' N 090°23.770' E	0.09-0.1	0.097±0.006	0.169±0.101	0.698

21.	Shib Bari	23°43.725' N 090°23.776' E	0.1-0.12	0.11±0.01	0.193±0.017	0.794
22.	DU Medical centre	23°43.703' N 090°23.805' E	0.14-0.16	0.15±0.01	0.263±0.017	1.083
23.	Annex Building	23°43.699' N 090°23.838' E	0.12-0.14	0.13±0.01	0.228±0.017	0.938
24.	Annex Building Gate	23°43.669' N 090°23.845' E	0.12-0.14	0.13±0.01	0.228±0.017	0.938
25.	Dhaka Medical College Hospital (DMCH)	23°43.560' N 090°23.911' E	0.1-0.12	0.11±0.01	0.193±0.017	0.794
26.	DMC Administrative Building.	23°43.586' N 090°23.879' E	0.17-0.18	0.177±0.006	0.309±0.010	1.275
27.	DMC Outdoor	23°43.634' N 090°23.838' E	0.14-0.16	0.15±0.01	0.263±0.017	1.083
28.	DMC	23°43.614' N 090°23.811' E	0.16-0.18	0.17±0.01	0.298±0.017	1.227
29.	DMC Radiology	23°43.573' N 090°23.810' E	0.18-0.20	0.19±0.01	0.333±0.017	1.372
30.	DMC cafe	23°43.540' N 090°23.850' E	0.16-0.18	0.17±0.01	0.298±0.017	1.227
31.	Institute of Nuclear Medicine and Allied Sciences (INMAS), Dhaka	23°43.524' N 090°23.792' E	0.12-0.14	0.13±0.01	0.228±0.017	0.938
32.	Beside of INMAS, Dhaka	23°43.503' N 090°23.779' E	0.16-0.18	0.17±0.01	0.298±0.017	1.227
33.	DMC B gate	23°43.496' N 090°23.745' E	0.17-0.18	0.173±0.006	0.304±0.010	1.251
34.	BUET gate	23°43.589' N 090°23.721' E	0.12-0.14	0.13±0.01	0.228±0.017	0.938
35.	BUET 1	23°43.596' N 090°23.687' E	0.15-0.16	0.157±0.006	0.274±0.010	1.131
36.	BUET 2	23°43.611' N 090°23.663' E	0.12-0.14	0.13±0.01	0.228±0.017	0.938
37.	BUET 3	23°43.600' N 090°23.613' E	0.13-0.14	0.137±0.006	0.239±0.01	0.987
38.	BUET 4	23°43.567' N 090°23.600' E	0.14-0.16	0.15±0.01	0.263±0.017	1.083
39.	BUET 5	23°43.575' N 090°23.566' E	0.16-0.17	0.163±0.006	0.286±0.01	1.107
40.	BUET 6	23°43.579' N 090°23.533' E	0.13-0.14	0.133±0.006	0.234±0.01	0.963
41.	BUET 7	23°43.581' N 090°23.511' E	0.17-0.18	0.177±0.006	0.309±0.01	1.276
42.	BUET 8	23°43.627' N 090°23.508' E	0.10-0.13	0.117±0.015	0.204±0.027	0.842
43.	BUET 9	23°43.663' N 090°23.504' E	0.17-0.18	0.177±0.006	0.310±0.01	1.275
44.	BUET 10	23°43.656' N 090°23.412' E	0.12-0.15	0.14±0.017	0.245±0.03	1.011
45.	BUET 11	23°43.647' N 090°23.388' E	0.10-0.11	0.103±0.006	0.181±0.01	0.746

46.	Salimullah Muslim (SM) Hall 1	23°43.671' N 090°23.418' E	0.12-0.14	0.13±0.01	0.228±0.0175	0.938
47.	SM Hall 2	23°43.689' N 090°23.467' E	0.14-0.16	0.15±0.01	0.263±0.0175	1.083
48.	SM Hall 3	23°43.707' N 090°23.516' E	0.13-0.14	0.133±0.006	0.234±0.010	0.963
49.	UDAYAN School	23°43.740' N 090°23.513' E	0.05-0.08	0.067±0.015	0.117±0.027	0.481
50.	Tower Building.	23°43.783' N 090°23.515' E	0.17-0.18	0.177±0.006	0.309±0.0102	1.276
51.	Beside British Council	23°43.825' N 090°23.505' E	0.12-0.14	0.13±0.01	0.228±0.0175	0.938
52.	British Council	23°43.848' N 090°23.509' E	0.12-0.13	0.127±0.006	0.222±0.0101	0.914
53.	DU Residential	23°43.893' N 090°23.521' E	0.18-0.20	0.19±0.01	0.333±0.017	1.372
54.	DU Fular road	23°43.937' N 090°23.488' E	0.12-0.14	0.13±0.01	0.228±0.017	0.939
55.	Vice-Chancellor (VC) Chattar	23°43.978' N 090°23.479' E	0.10-0.11	0.103±0.006	0.181±0.010	0.746
56.	VC Chattar 2	23°43.995' N 090°23.524' E	0.12-0.14	0.13±0.01	0.228±0.017	0.938
57.	VC Chattar 3	23°43.989' N 090°23.575' E	0.11-0.13	0.12±0.01	0.210±0.017	0.866
58.	Near Rokeya Hall	23°43.980' N 090°23.650' E	0.18-0.19	0.183±0.006	0.321±0.010	1.324
59.	Rokeya Hall	23°43.965' N 090°23.675' E	0.16-0.18	0.17±0.01	0.298±0.017	1.227
60.	Mishuk Munir Chattar	23°43.888' N 090°23.713' E	0.09-0.10	0.097±0.006	0.169±0.010	0.698
61.	SN Hall	23°43.865' N 090°23.719' E	0.10-0.11	0.107±0.006	0.187±0.010	0.770

From this study (Table no.01) noticed that the gamma dose rate range lies between 0.067±0.015 μSv/h to 0.19±0.01 μSv/h with the mean value of 0.138±0.009 μSv/h. The minimum absorbed gamma dose of 0.067±0.015 μSv/h is in Udayan School (23°43.740´ N, 090°23.513´ E). The maximum absorbed gamma dose in both the Radiology Department of Dhaka Medical College (DMC) (23°43.573' N, 090°23.810' E) and Dhaka university residential area (23°43.893' N, 090°23.521' E) is 0.19±0.01 μSv/h. The annual effective dose of this particular area lies between 0.117±0.027 mSv/yr to 0.333±0.017 mSv/y, and the mean value to the monitoring point is 0.242± 0.016mSv/y. Where the minimum annual effective dose recorded at Udayan School (23°43.740´ N, 090°23.513´ E) is 0.117±0.027 mSv/yr, and the maximum annual effective dose was recorded in both the Radiology Department of Dhaka Medical College (23°43.573' N, 090°23.810' E) and DU residential area (23°43.893' N, 090°23.521' E) is 0.333±0.017 mSv/y.

From the graphical presentation (figure 02), the difference among the annual effective dose of each monitoring point is not high. The annual effective dose of every monitoring point is lower than the permissible limit for public 1 mSv/y. The average annual effective dose for this studied area is 0.242 mSv/y less than the permissible limit. The value of the annual effective dose of each point is not the same. The reason behind this might be the geographical location or any other.

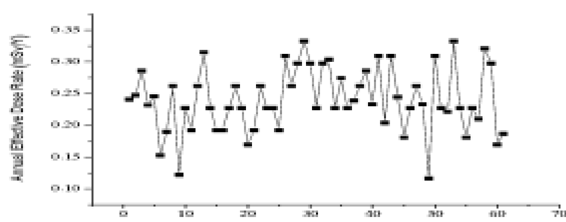

Figure 02: Graphical representation of annual effective dose rate to monitoring point.

From the frequency distribution curve (Fig. 3), it can say that a large number of the annual effective dose lies in value between 0.220 mSv/y to 0.240 mSv/y. Very few effective doses got values lower than 0.175 mSv/y and upper than 0.30 mSv/y.

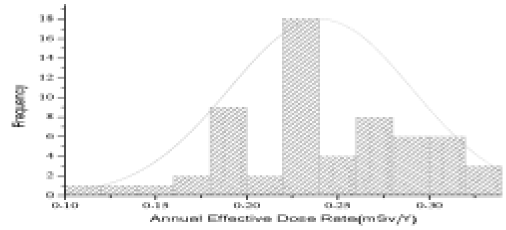

Figure 3: Frequency distribution curve of annual effective dose rate.

Table 02: Environmental gamma dose rate range and annual effective dose range due to natural radionuclides sources for various countries and this study (UNSCEAR, 2008) [13,8,1].

Country	Range of dose rate (µSv/h)	Mean Gamma dose rate (µSv/h)	Range of annual effective dose (mSv/y)
Libyan Arab Jamahiriya	0.048 - 0.054	0.051	0.059 - 0.066
Mauritius	0.08 - 0.126	0.098	0.098 - 0.155
Tanzania (United Rep. of)	0.098 - 0.121	0.104	0.120 - 0.148
Canada	0.031 – 0.075	0.054	0.038 – 0.092
Mexico	0.023 – 0.184	0.088	0.028 – 0.226
Costa Rica	0.035 – 0.147	0.066	0.043 – 0.180
Odisha, India	0.251 – 0.879	0.449	0.308 – 1.078
Cuba	0.038 – 0.196	0.055	0.047 – 0.240
Azerbaijan	0.075 – 0.205	0.140	0.092 – 0.251
Islamic Republic of Iran	0.036 – 0.130	0.112	0.063 – 0.228
China	0.011 – 0.523	0.815	0.013 – 0.641
Indonesia	0.045 – 0.102	0.0675	0.055 – 0.125
Indonesia (Karimu Island)	0.200 – 0.410	0.310	0.350 – 0.718
Korea	0.018 – 0.200	0.079	0.022 – 0.245
Turkey	0.032- 0.094	0.065	0.039 – 0.115
Denmark	0.056 – 0.010	0.066	0.069 – 0.124
Finland	0.077 – 0.171	0.103	0.094 - 0.209
Lithuania	0.079 – 0.115	0.095	0.097 – 0.141
Sweden	0.040 – 0.630	0.097	0.049 – 0.773
Belgium	0.045 – 0.102	0.076	0.055 – 0.125
Ireland	0.035 – 0.143	0.065	0.043 – 0.175
Italy	0.057 – 0.243	0.112	0.069 – 0.298
Italy (Lazio)	0.120 – 0.270	0.175	0.210 – 0.473
Spain	0.050 – 0.129	0.085	0.061 – 0.158
Switzerland	0.053 – 0.155	0.081	0.065 – 0.190
Bulgaria	0.075 – 0.140	0.100	0.092 – 0.172
Czech Republic	0.040 – 0.285	0.100	0.049 – 0.349
Poland	0.051 – 0.126	0.080	0.063 – 0.155
Romania	0.052 – 0.163	0.092	0.065 – 0.199
Albania	0.077 – 0.103	0.094	0.094 – 0.126
Croatia	0.070 – 0.140	0.115	0.086 – 0.172
New Zealand	0.034 – 0.122	0.076	0.042 – 0.149
This Study	**0.067 - 0.190**	**0.138**	**0.117 – 0.333**

From table 02, annual effective dose due to gamma radiation from natural radiation source in this study is lower than the India (Odisha), Indonesia (Karimu Island), Italy (Lazio) and higher than others. United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) mentioned the worldwide average outdoor dose rate from the natural radiation source is 59 nGy/h, and the mean public effective environmental gamma dose rate is 0.072 mGy/y [14]. From this study, the mean gamma dose rate for the people of this area is 2.33 times greater than the average world value. Also, the average annual effective dose for the public is 1.6 to 4.6 times greater than the world average limit. According to ICRP 103 (2007 recommendation), the permissible annual effective dose limit is 1mSv/y [15].

3.2 Excess lifetime cancer risk:

Figure 04 shows excess lifetime cancer risk, and this value lies in the range of 0.48×10^{-3} ~ 1.37×10^{-3} with an average value of 0.99×10^{-3}. The average value of ELCR in this study is greater than the world average ELCR value of 0.29×10^{-3} [16-19].

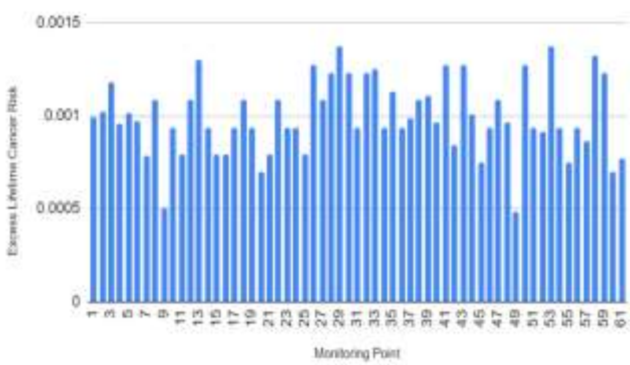

Figure 04: Excess lifetime cancer risk for reference monitoring points.

4 Discussions

In this study, outdoor environmental radiation doses according to gamma radiation source were measured with a digital survey meter by following a valid method in and around 61 monitoring points of the Dhaka university campus area. As per the recommendation of ICRP, the permissible limit of annual effective dose is 1 mSv/yr [15], so the measured mean annual effective dose for this studied area of 0.242 mSv/yr has no significant contribution to radiation hazards to the human body. As Bangladesh is a developing country and dhaka is an overpopulated city in Bangladesh and in the world. Various mega projects are running in this country, like Rooppur Nuclear Power Plant and the Dhaka Metro Rail project. A large part of this metro rail line is under construction over the Dhaka university campus. It is well known that building materials made from terrestrial components mainly emit radiation less or more. This type of monitoring is significant for this type of developing country like Bangladesh. Increased radioactivity use in multiple purposes like medical facilities, industrial work, nuclear-related research, and development. Overall, real-time radiation monitoring effectively creates a baseline database of any area. If any accident occurs due to nuclear facilities installation in this area or any other area beside or outside of our country can be detected by this survey. Last, of all, from this present study, there is no critical situation of nuclear radiation, and the dose that exists in the environment of the Dhaka university campus area is not much hazardous to public health. But if the dose limit increase, it will be a sign of danger. So the respected user facilities and personnel would be more aware of handling these instruments and should minimize the use of nuclear and radiological facilities. We should follow the ALARA principle and maintain the minimal use of radioactive elements. From this study, the excess lifetime cancer risk is comparatively higher than the average world value. People should minimize the use of a technique that involves radiation, like radiological imaging. To lead a healthy life should be avoided unnecessary radiological use [20-21].

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