Short Communication

Measurement of Environmental Gamma Dose at AECD Campus of Bangladesh

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Abstract

A portable HPGe detector has been employed to assess environmental gamma-ray dose following in-situ technique from the primordial radionuclide ^{40}K in the soil at 15 monitoring points (MPs) in the environment at the Atomic Energy Centre, Dhaka (AECD) campus, Bangladesh. The MPs were marked-out using Global Positioning System (GPS) navigation. The measured dose rate due to ^{40}K range from 0.0428 $\mu Gy.h^{-1}$ to 0.1222 $\mu Gy.h^{-1}$ with an average of 0.0828 ± 0.0225 $\mu Gy.h^{-1}$.

1. Introduction

Studies on the high background radiation areas in the world have been of prime importance for risk estimation due to the problem associated with long-term whole-body irradiation [1]. Gamma-ray spectroscopy system provides practical way to characterize dispersed radionuclides in or on the soil to ascertain possible changes in the environmental radioactivity. Both laboratory and in-situ gamma spectroscopy are often used for monitoring and assessment of radioactivity and radiation dose rates in the environment due to both natural and anthropogenic sources [2-7]. In large- scale environmental radioactivity measurement, in-situ gamma-ray spectroscopy is much favoured compared to laboratory soil analysis because of time and problems associated in cross contamination involved in the laboratory methods. It also gives the opportunity to obtain information not only of the activity concentration but also of the relative contribution of the various nuclides to activity concentration. In-situ techniques for

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measuring the activity concentration resulting from the gamma radiation and characterizing its sources with gamma ray spectrometer have been used successfully in the outdoor environment [2, 8-10].

For radiation monitoring near nuclear facilities, baseline data, are indispensable for various purposes: they provide documented reference base; for the assessment of actual or potential consequence of radioactivity on health and on the environment due to radioactive materials or radiation fields in the environment from normal operations and accidental releases. The present work has been conducted in the Atomic Energy Centre, Dhaka (AECD) Campus using high- resolution portable gamma spectroscopy system. The AECD is a nuclear energy (radiation) based research centre, thus, dealing with some calibration artificial radioactive sources/materials such as ^{137}Cs, ^{60}Co, [192] Ir, etc.

The theoretical principles of in-situ gamma-ray spectrometry were developed in the early 1970s [2]. The three-factor assay formula is given by

$$\frac{N_f}{I} = \frac{N_f}{N_o} \cdot \frac{N_o}{\Phi} \cdot \frac{\Phi}{I} \tag{1}$$

where N_f is the full-energy peak count rate of the measured radionuclide (in counts per second), No is the full-energy peak count rate of that radionuclide for a parallel beam of gamma-rays that is incident on the detector parallel to its symmetry axis, Φ is the gamma-ray un-scattered flux on the detector ($cm^{-2}.s^{-1}$) and I is the exposure rate ($\mu R/hr$). Φ/I is the ratio of the flux due to gamma-rays of energy E to the corresponding exposure rate for that nuclide; this value was taken from Beck's tabulated data [2] and it is expressed in ($\gamma.s^{-1}.cm^{-2}/\mu R.h^{-1}$).

The gamma dose rate can be calculated by the formula:

$$\dot{D} = k \sum_i \frac{(N_f)_i}{(N_f / I)_i} \tag{2}$$

where the sum is extended over all the peaks registered by the detector; $(N_f)_i$ are the counts per second of the peaks experimentally measured and k is the conversion factor from Roentgen to Gray.

The objective of the present study is to measure in-situ environmental gamma-ray dose rate due to [40]K at Atomic Energy Centre, Dhaka (AECD) campus.

2. Materials and Method

2.1. *In-Situ gamma-ray spectrometer*

An Ortec HPGe detector was used. It is a portable instrument with a p-type crystal, a dewar for the liquid nitrogen along with digiDART. Gamma –ray spectra were measured by a tripod-mounted, downward-facing HPGe detector (Ortec, Model: GEM25P4-83, CFG: POPTOP, Serial No.: 50-TP12792A) of 25% relative efficiency within the energy

range 50 keV-2 MeV compared with a 3 in. by 3 in. NaI(Tl) detector and 1.70 keV FWHM (both at 1332 keV) energy resolution, located 1m above ground. Spectra of 8192 channels were analyzed by the Maestro-32 MCA Emulsion Software.

2.2. Gamma-ray calibration sources

Measurement of *No/Φ* was performed at a 1m distance by a fixed radionuclide gamma-ray standard sources containing the following radionuclides (energies in keV, emission probabilities in %): ^{133}Ba (276.398, 7.164; 302.853, 18.33; 356.017, 62.05; 383.851, 8.94), ^{137}Cs (661.660, 85.1), ^{60}Co (1173.237, 99.90; 1332.501, 99.982). Gamma-ray emission rates of the standards were calculated from the standards, certificates, correcting from the lapse of time from the reference date. The flux is given by the gamma-ray emission rate divided by 4π and by 1m^2 (100^2 cm^2). A second order polynomial least-squares fitting determined the log(*No/Φ*) versus log(gamma-ray energy) dependence, which is followed by the equation, ln (*No/Φ*) = 4.48-1.03ln*E* where *E* is in MeV.

2.3. The site

The study site is located at 90°23.748′-90°23.829′E and 23°43.836′-23°43.836′N. The number of monitoring points was 15 as shown in Table 2. Table 2 gives the description of the monitoring points (MP). These sites were marked out using Global Positioning System (GPS).

Table 1. The features of the detector used in this study.

Description	Detector
Detector type (ORTEC)	Coaxial P-type
HPGe crystal length (mm)	64.8
HPGe crystal diameter (mm)	53.5
HPGe crystal hole diameter (mm)	9.9
HPGe crystal hole depth (mm)	51.1
End-cup type	1mm Al
Relative efficiency (^{60}Co gamma-ray at 1332 keV)	25%
Peak shape (FWTM/FWHM) for ^{60}Co	1.9 keV
Peak shape (FWTM/FWHM) for ^{60}Co	2.6 keV
Resolution (FWHM) at 1332keV, ^{60}Co	1.85 keV
Resolution (FWHM) at 122keV, ^{57}Co	820 eV
HPGe cooling system	Liquid nitrogen
Positive high voltage (V)	3800

3. Results and Discussion

3.1. *Determination of dose rate*

3.1.1. *Determination of N_f/I*

N_f/I value was obtained from Eq. 1 where N_f/N_o = angular correction factor, which for the detector used was assumed to be one, in the energy range of interest (50-2000 keV).

Φ/I is the ratio of the flux due to gamma-ray of energy E to the corresponding exposure rate for that nuclide; this value was taken from Beck's tabulated data [2] and it is expressed in $\gamma.s^{-1}.cm^{-2}/(\mu R.h^{-1})$.

For ^{40}K (1460 keV), $\Phi/I =0.203 \ \gamma.s^{-1}.cm^{-2}/(\mu R.h^{-1})$

No/Φ = the count rate under a peak area due to unit flux of energy E incident of the detector parallel to its axis of symmetry; it is determined experimentally and it is express in $cps/ \ \gamma.s^{-1}.cm^{-2}$, which is obtained from the graph of Fig. 1.

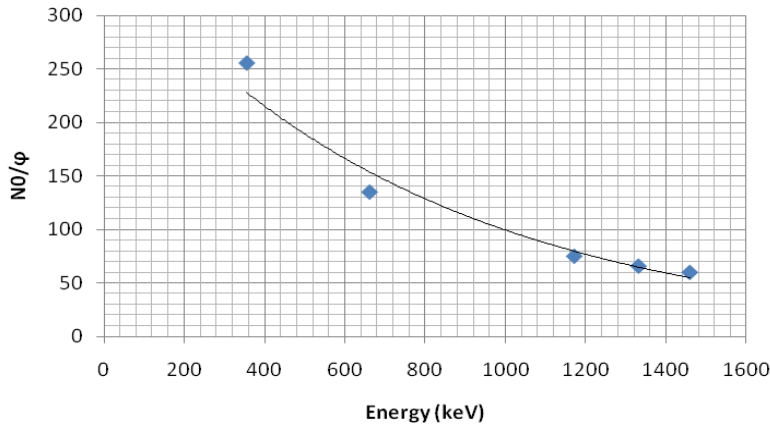For ^{40}K (1460 keV), $No/\Phi = 60 \ cps/ \ \gamma.s^{-1}.cm^{-2}$

Fig. 1. Variation of *No/φ* with energy.

Inserting the above values into Eq. 1, we obtained the value of N_f/I = 12.18 $cps/(\mu R.h^{-1})$. Then following Eq. 2, the dose rate was calculated as shown in Table 2 below for different monitoring points.

Table 2. Dose rate due to ^{40}K.

SI.	Location and date	GPS	Time of measurement (sec)	Total counts in the peak	N_f/I (cps/μR/h)	Dose rate (μGy.h^{-1})
1.	12062013	N:23°43.853′ E:90°23.809′	10000	3733 ± 61	12.18	0.0963
2.	13062013	N:23°43.853′ E:90°23.816′	10000	3273 ± 57	12.18	0.0844
3.	16062013	N:23°43.864′ E:90°23.803′	10000	3939 ± 62	12.18	0.1024
4.	21042013	N:23°43.862′ E:90°23.763′	10000	3278 ± 57	12.18	0.0846
5.	23042013	N:23°43.850′ E:90°23.823′	10000	3305 ± 57	12.18	0.08525
6.	25042013	N:23°43.845′ E:90°23.825′	10000	3700 ± 57	12.18	0.0955
7.	26022013	N:23°43.870′ E:90°23.812′	10000	4157 ± 64	12.18	0.1065
8.	01042013	N:23°43.861′ E:90°23.748′	10000	4736 ± 68	12.18	0.1222
9.	04032013	N:23°43.838′ E:90°23.781′	10000	3085 ± 55	12.18	0.07946
10.	04042013	N:23°43.836′ E:90°23.785′	10000	3921 ± 62	12.18	0.1004
11.	29042013	N:23°43.875′ E:90°23.801′	10000	2272 ± 47	12.18	0.05851
12.	17062013	N:23°43.865′ E:90°23.819′	10000	1810 ± 42	12.18	0.04675
13.	23072013	N:23°43.845′ E:90°23.763′	10000	2808 ± 53	12.18	0.07248
14.	02092013	N:23°43.872′ E:90°23.813′	10000	2508 ± 50	12.18	0.06462
15.	03092013	N:23°43.854′ E:90°23.817′	10000	1670 ± 41	12.18	0.04279

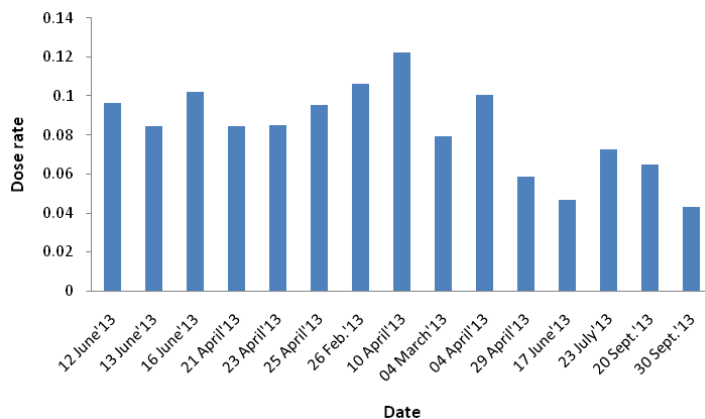The above dose rate in Table 2 is comparable with other authors published in international journal [11].

Fig. 2. Dose rate due to ^{40}K at different monitoring points.

The value obtained with in-situ gamma spectrometry is lower than those obtained with survey meter. The dose obtained with survey meter varied in the range of 0.21-0.22 μSv.h^{-1}. These results can easily be explained by the fact that in-situ gamma-ray spectrometry does not consider the cosmic-ray contribution to the dose because the detector is kept facing downward. At the altitude and latitude of the measurement location, the cosmic ray dose rate is about 0.037 ± 0.005 μGy.h^{-1} (UNSCEAR 2000). However, even after this correction, the difference between the dose value from Survey meter and that from the gamma-ray spectrometry is still significant.

This apparent underestimation of the dose obtained with in-situ gamma spectrometry can be explained by a number of reasons:

a. the standard soil parameters adopted in the calculation (soil density and moisture, for example) could be different from those experimentally encountered;
b. the relatively short acquisition time of the spectrum could not allow the detection of some peaks that contribute to the total dose;
c. the drop of the energy response at high energy (> 2 MeV) may affect the evaluation of some important gamma emissions with high energy, such as the ^{208}Tl emission (2614.6 keV).

Table 2 shows the dose rate at 15 MPs of AECD campus which is comparable with those published by other authors [11].

The assessment of the radionuclide level of the area did not detect the presence of any artificial radionuclide and thus no significant impact of the extensive usage of radioactive materials/sources within and around the centre. This kind of study is required to detect the

presence of natural radionucldes and artificial radionuclides (if any) releasing from nuclear installations in the country or neighbouring countries.

4. Conclusion

In-situ gamma-ray spectrometry utilizing portable HPGe detector is a reliable, selective and rapid technique for the determination of local radioactivity and dose rates in surveyed areas. The measured dose rate due to ^{40}K range from 0.0428 μGy.h^{-1} to 0.1222 μGy.h^{-1} with an average of 0.0828 ± 0.0225 μGy.h^{-1}.The assessment of the radionuclide level of the area did not detect the presence of any artificial radionuclide and thus no significant impact of the extensive usage of radioactive materials within and around the AECD and no radiation burden of the environment. This kind of study is required to detect the presence of natural radionucldes and artificial radionuclides (if any) releasing from nuclear installations in the country or neighbouring countries.

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