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Study of the radiological dose rates and hazard indices in soil samples collected from Northern part of Chittagong City Corporation, Chittagong, Bangladesh

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ABSTRACT

To evaluate natural radionuclide radiological doses and hazard indices ^{238}U, ^{232}Th and ^{40}K in soil samples were obtained from the Chittagong City Corporation region using a (HpGe) gamma-ray spectroscopy detector during the operation of the Bangladesh Atomic Energy Commission (BAEC).The results showed that the radiological hazard parameters of the mean values of absorbed gamma-ray dose rate, annual effective dose equivalent, annual gonadal dose equivalent, gamma representative level index, and external hazard index were calculated to be 63.59±10.38 nGy/h, 77.99±12.74 μSv/y, 446.85±73.22μSv/y, 1.004±0.164 and 0.371±0.061 respectively. All the values obtained in the present study are compared with different countries and there are no detrimental radiological health consequences for the residents of the area.

Keywords: Annual effective dose, absorbed dose, gonadal dose and HpGe.

1. Introduction

The most important global interest in the observation as well as research of naturally occurring radiation and the necessity to use implications from some reviews the measuring of general radiation exposure rates has always been based on radioactivity.The overall depiction of epidemiologic tracings, as well as radiometric pertinent data, are utilized to determine possible alterations owing to nuclear medicine centers, industry, and man-made technologies used in environmental radioactivity. (UNSCEAR, 2000)[3].The common natural radioactivity in representative soil pre-eminently enters from the uranium and thorium decay series as well as potassium decay series. The exact radiation level might be caused by the radionuclide content of representative soil that varies broadly from one place to another place. The exact background contribution to the external gamma dose rate at a particular geological position can be ascertained only by assessment.

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So the dose rate depends on the geological and geographical positions. In several countries, natural background radiation assessment and radioactivity in representative soil have been measured to set up the baseline data levels for natural radiation [1].

Radioactivity existed in our world when it was created. As a result over 60 radionuclides are often observed as well as they might be positioned in three categories: [4].

1. Primordial – it existed since the creation of the earth which equals to the half-lives of the radionuclides are the age of the universe (15 billion years).
2. Cosmo genic – it is created and restocked by the cosmic ray interactions.
3. Human produced– it is measured accurately and controlled very strictly to avoid releasing it into the flora and fauna environment and living tissue.

At least 22 naturally occurring single or not-series primordial radionuclides have been destined. The majority of radionuclides have such long half-lives, abundances of material, little isotopic as well as little biological uptake. They give a little environmental dose

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of the activity concentration except for Potassium-40 which is the most important [5]. Radionuclides are going to be measured naturally in air, groundwater, and soil, they have a tendency to be symmetric measured prospering within our human body, being that we are constituents of our environment. Natural radioactivity is a common occurrence in the earth's soil [6].In general, a feature in radionuclides hazards qualitative measurement of the biological, chemical, and physical which are employed in the food chain is required. As a result of radiation from the earth's crust and cosmos, it's emitted from both natural and artificial radionuclides which surround us at each moment. [1,2]. The values of background dose rate change from one place to another place which depends mainly on the mineral content in the ground and the intensity of cosmic rays. Interactions are held between cosmic radiation and the atmosphere to leadto the production of numerous Cosmo genic radionuclides. Therefore we can find various levels of radionuclides in the representative soil samples in a different areas in Chittagong City Corporation.

2. Materials and Methods

2.1 Systematic grid sampling

The general strategy to get in orderly soil sampling undergo surface layer a square or rectangular grid on the map of the study area, differentiate as well as drive to the center of each grid and then collect sample at the center point. (Figure 2 a).The soil nodes have been concerted along with together soil sample qualitative analysis also at a radioactivity testing and monitoring laboratory. Individual sample nodes are mixed with the goal of reducing variation in soil test properties, which could lead to an increase in distances. The grid cell representative sample may be appropriately performed by counting rows that use distance measurement devices to find sampling points. The possibility of bias is often decreased via variable representative sample areas to the right or left of the grid cell center interchanging rows vertical to the overall management pattern. After all representative sample grid gets the appearance of a diamond model (Figure 2 b). This model of sampling may also be enforced by way of counting rows and ascertaining distances. Using the development of the Global Positioning System (GPS), if any problem is faced when traveling in the study area we have moved to specific locations inside a study area without having to count rows. As farm level GPS hardware and software become available, we accept a strategy to adopt a representative sample draft that is systematic and impartial. This system consists of a systematic representative sample and a random representative sample [7].

Sample no.	Ward No. of the City Corporation	Local Name of the Sample collection area	Geographical position	
			Latitude	Longitude
$S_s - 1$	CCW-1	NandirDighi (Nandir Hat)	N22^{0}27′05.9″	E91^{0}49 ′02.2″
$S_s - 2$	CCW-1	BoroDighir par	N22^{0}26′07.3″	E91^{0}49 ′03.1″
$S_s - 3$	CCW-1	Natunpara(Chikondandi)	N22^{0}25′05.2″	E91^{0}49 ′07.0″
$S_s - 4$	CCW-2	Kulgong(Mazar gate)	N22^{0}24′03.1″	E91^{0}49 ′02.9″
$S_s - 5$	CCW-2	Kuaish	N22^{0}24′04.8″	E91^{0}50′02.0″
$S_s - 6$	CCW-2	Saheed Nagar (Pathanpur)	N22^{0}24′02.1″	E91^{0}51 ′03.2″
$S_s - 7$	CCW-3	Bayezeed (Pharika R/A)	N22^{0}23′02.4″	E91^{0}49 ′03.2″
$S_s - 8$	CCW-4	Kalurghat Road (Sunnia Madrasa)	N22^{0}23′04.1″	E91^{0}50 ′01.5″
$S_s - 9$	CCW-4	Bohaddar hat	N22^{0}23′03.4″	E91^{0}51 ′04.0″
$S_s - 10$	CCW-4	Sulokbahar (Sunnia Madrasa)	N22^{0}23′01.3″	E91^{0}52 ′02.2″
$S_s - 11$	CCW-9	Foy's Lake	N22^{0}22′02.1″	E91^{0}48 ′03.2″
$S_s - 12$	CCW-7	Sholoshahar (Rail Line)	N22^{0}22′06.6″	E91^{0}49 ′06.1″
$S_s - 13$	CCW-5	Al-Falah Mosque	N22^{0}22′02.5″	E91^{0}50′01.7″
$S_s - 14$	CCW-5	Chawk Bazar Road	N22^{0}22′05.1″	E91^{0}51 ′02.5″
$S_s - 15$	CCW-10	Uttar kattli	N22^{0}21′02.1″	E91^{0}48 ′01.3″
$S_s - 16$	CCW-10	Ishpahani Hall	N22^{0}21′03.1″	E91^{0}49 ′01.2″
$S_s - 17$	CCW-6	West bakalia	N22^{0}21′03.4″	E91^{0}50 ′02.1″

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$S_s - 18$	CCW-10	South Kattli	N22^{0}20′01.1″	E91^{0}47 ′02.2″
$S_s - 19$	CCW-10	Sarai Para	N22^{0}20′02.3″	E91^{0}48′01.1″
$S_s - 20$	CCW-8	Eidgah (Kacha Rasta)	N22^{0}20′03.1″	E91^{0}49′02.2″
$S_s - 21$	CCW-8	Station Polo Ground	N22^{0}20′02.1″	E91^{0}50′01.2″

S_s = Soil sample; CCW = Chittagong City Corporation Ward

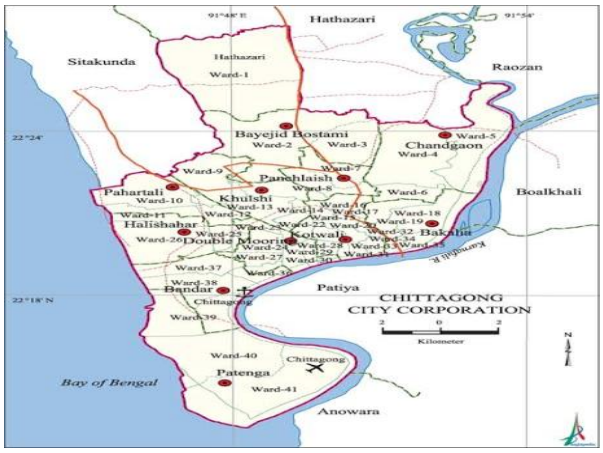

Fig. 1 (a): Location of sample collection in Chittagong City Corporation.

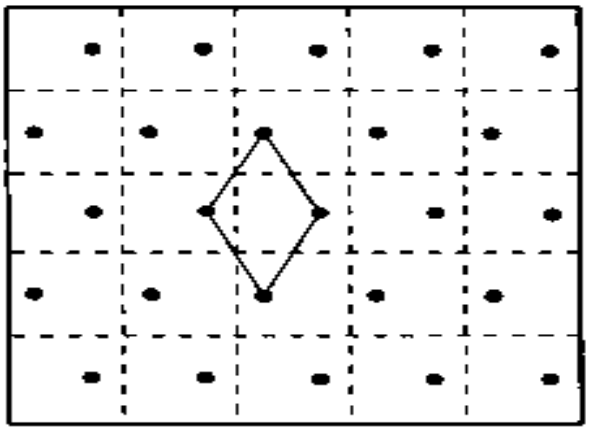

Fig. 2 (a): Collection of the soil sample at the systematic grid point.

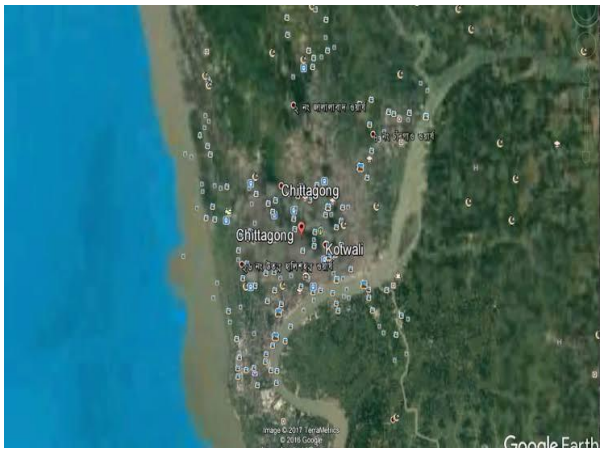

Fig. 1 (b): The sampling location of two areas of Chittagong City Corporation in Google earth.

Fig. 2 (b): Collection of the soil sample at the systematic grid point.

2.2 HpGe detector calibration

A solid matrix source was used to determine the detector calibration efficiency which was prepared by the International Atomic Energy (IAEA) reference samples. RGU-1, Uranium is in silica matrix, RGTh-1: Thorium is in silica matrix and RGK-1: potassium Sulphate are standard samples which are referred by IAEA.The standard representative reference sources have the same diameter as the representative soil samples of defined concentrations of ^{238}U, ^{232}Th and ^{40}K

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radionuclides supplied by the Canada Centre for Mineral and Energy Technology (CAMET) under an agreement with the IAEA. The detector efficiency calibration curves as a function of energy for both solid matrices have been shown in Figure 3 [6].

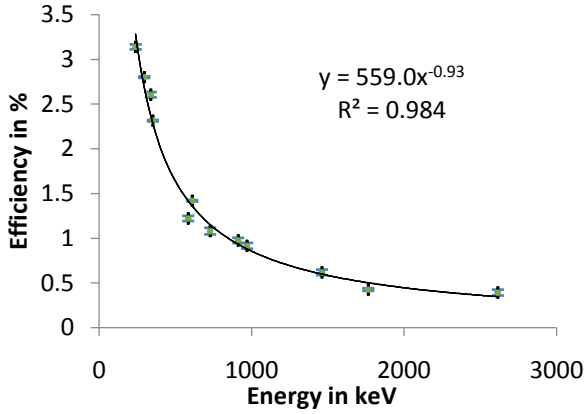

Fig. 3: HpGe Detector efficiency curve.

2.3 Measurement of activity concentration

The overall efficiency of the detector was measured through the use of the formula [8],

$$\text{Efficiency } (\varepsilon_f\%) = \frac{CPS \times 100}{\text{Activity} \times Intensity}$$

$$\text{or, Efficiency } (\varepsilon_f\%) = \frac{CPS \times 100}{\text{Ac} \times I_\gamma}$$

The activity of natural radionuclides are commenced in the representative soil samples were measured through the use of the formula [9],

$$\text{Activity } (A_c) = \frac{CPS \times 100 \times 1000}{\varepsilon_f(\%) \times I_\gamma \times W_s(gm)}$$

Where, CPS = Sample CPS – Background CPS)

CPS = the efficiency of the detector counting by gamma energy.

I_γ = gamma − ray intensity.

A_c = Natural radionuclides activity concentration.

W_s = Sample weight.

The uncertainty of the assessments was expressed in terms of standard deviation (±1σ).

2.4 Measurement of the radiological dose rates and hazard indices

Absorbed gamma-ray dose rate (D):

In the UNSCEAR report 2008,natural radionuclides absorbed dose rate in air 1 meter above the ground surface was measured through the use of a formula [12].

$$\text{D(nGy/h)} = 0.462A_U + 0.604\,A_{Th} + 0.0417A_K \ldots\ldots (1)$$

Annual effective dose equivalent (AEDE):

Natural radionuclides annual effective dose equivalent was measured through the use of the formula [12].

$$AEDE\ (\mu Sv/y) = D(nGy/h) \times 8760(h) \times 0.2 \times 0.7(Sv/Gy) \times 10^{-3} \ldots\ldots\ldots (2)$$

Annual gonadal dose equivalent (AGDE):

Natural radionuclides annual gonadal dose equivalent was measured through the use of the formula [13].

$$AGDE\ (\mu Sv/y) = 3.09A_U + 4.18\,A_{Th} + 0.314\,A_K \ldots\ldots\ldots\ldots (3)$$

Gamma representative level index ($I_{\gamma r}$):

Natural radionuclides gamma representative level index was measured through the use of the formula [14].

$$I_{\gamma r} = \frac{A_U}{150} + \frac{A_{Th}}{100} + \frac{A_K}{1500} \ldots\ldots\ldots (4)$$

Hazard index (H_{ex}):

Natural radionuclides external hazard index was measured through the use of the formula [15].

$$H_{ex} = \frac{A_U}{370} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \leq 1 \ \ldots\ldots\ldots\ldots (5)$$

3. Result and Discussions

Radiation dangers are being assessed as part of the process of assessing the health consequences of the natural radionuclides such as absorbed gamma-ray dose rate, annual effective dose equivalent and annual gonadal dose, gamma representative level index and external hazard index have been measured from the activity of nuclides ^{238}U, ^{232}Th and ^{40}K using following equations and the values have been shown in table B and table C. In the present study, reference samples of the International Atomic Energy Agency (IAEA) were used for the detector efficiency calibration. The IAEA reference samples are (1) IAEA/RGU-1: Uranium ore in silica powder containing radionuclides or components ^{238}U, ^{232}Th and ^{40}K ; (2) IAEA/RGTh-1: Thorium ore in silica powder containing radionuclides or components ^{238}U, ^{232}Th and ^{40}K; (3) IAEA/RGK-1: Extra pure

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Potassium sulphate containing radionuclides or components U, Th and K. The standard source has known concentration of ^{238}U, ^{232}Th and ^{40}K radionuclides supplied by Canada Center for Mineral and Energy Technology (CAMET) under a contract with IAEA. The specification of the recommended standard source is shown in Table A.

Table A: Specifications of the standard sources

Radio-nuclides	Sample name	Date of reference	Re-commended activity in Bq/kg	Confidence interval in Bq/kg	Weight of sample in gm	Activity in Bq/kg
^{238}U	IAEA/RGU-1	November 1987	4940±30	4910-4970	146.3	722.72±4.39
^{232}Th	IAEA/RGTh-1	November 1987	3250±90	3160-3340	126.10	409.83±11.35
^{40}K	IAEA/RGK-1	November 1987	14000±400	13600-14400	158.4	2217.60±63.36

Table B: The sample location and their corresponding geographical positions by Systematic grid sampling.

Sample No.	Date of collection	Date of preparation	Geographical position		Sample net weight(gm)
			Latitude	Longitude	
$S_s - 1$	14.07.2013	01.08. 2013	$N22^0 27' 05.9''$	$E91^0 49' 02.2''$	188.20
$S_s - 2$	14.07.2013	01.08.2013	$N22^0 26' 07.3''$	$E91^0 49' 03.1''$	182.20
$S_s - 3$	14.07.2013	01.08.2013	$N22^0 25' 05.2''$	$E91^0 49' 07.0''$	171.50
$S_s - 4$	14.07.2013	01.08.2013	$N22^0 24' 03.1''$	$E91^0 49' 02.9''$	193.31
$S_s - 5$	14.07.2013	01.08.2013	$N22^0 24' 04.8''$	$E91^0 50' 02.0''$	202.02
$S_s - 6$	30.07.2013	18.08.2013	$N22^0 24' 02.1''$	$E91^0 51' 03.2''$	150.05
$S_s - 7$	14.07.2013	01.08.2013	$N22^0 23' 02.4''$	$E91^0 49' 03.2''$	215.24
$S_s - 8$	17.07.2013	01.08.2013	$N22^0 23' 04.1''$	$E91^0 50' 01.5''$	170.17
$S_s - 9$	17.07.2013	18.08.2013	$N22^0 23' 03.4''$	$E91^0 51' 04.0''$	164.43
$S_s - 10$	17.07.2013	18.08.2013	$N22^0 23' 01.3''$	$E91^0 52' 02.2''$	187.88
$S_s - 11$	30.07.2013	18.08.2013	$N22^0 22' 02.1''$	$E91^0 48' 03.2''$	209.06
$S_s - 12$	08.06.2013	01.08.2013	$N22^0 22' 06.6''$	$E91^0 49' 06.1''$	159.49
$S_s - 13$	25.07.2013	18.08.2013	$N22^0 22' 02.5''$	$E91^0 50' 01.7''$	186.93
$S_s - 14$	17.07.2013	01.08.2013	$N22^0 22' 05.1''$	$E91^0 51' 02.5''$	206.30
$S_s - 15$	30.07.2013	18.08.2013	$N22^0 21' 02.1''$	$E91^0 48' 01.3''$	177.17
$S_s - 16$	30.07.2013	18.08.2013	$N22^0 21' 03.1''$	$E91^0 49' 01.2''$	187.43
$S_s - 17$	30.07.2013	18.08.2013	$N22^0 21' 03.4''$	$E91^0 50' 02.1''$	196.49
$S_s - 18$	30.07.2013	18.08.2013	$N22^0 20' 01.1''$	$E91^0 47' 02.2''$	166.24
$S_s - 19$	30.07.2013	18.08.2013	$N22^0 20' 02.3''$	$E91^0 48' 01.1''$	207.26
$S_s - 20$	30.07.2013	18.08.2013	$N22^0 20' 03.1''$	$E91^0 49' 02.2''$	165.00
$S_s - 21$	30.07.2013	18.08.2013	$N22^0 20' 02.1''$	$E91^0 50' 01.2''$	176.20

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Table C: Natural radionuclides activity concentrations, the radiological doses and hazard indices for all soil samples.

Sample no.	Activity concentration of natural radionuclides			Radiological doses and hazard indices				
	^{238}U	^{232}Th	^{40}K	Absorbed dose rate	Annual effective dose rate	Annual gonadal dose	Gamma R. index	Hazard index
$S_s - 1$	48.87 ± 6.00	64.71 ± 7.95	494.09 ± 78.79	82.27±10.86	100.9±13.32	576.64±76.51	1.302±0.172	0.485±0.063
$S_s - 2$	38.64 ± 5.68	53.79 ± 7.64	536.96 ± 61.03	72.73±9.78	89.20±12.00	512.85±68.65	1.153±0.155	0.424±0.058
$S_s - 3$	41.12 ± 5.75	45.00 ± 7.47	449.67 ± 77.94	64.93±10.42	79.63±12.78	456.36±73.47	1.024±0.165	0.378±0.061
$S_s - 4$	40.52 ± 5.77	51.49 ± 7.62	463.70 ± 78.20	69.16±10.53	84.81±12.91	486.04±74.24	1.094±0.167	0.405±0.061
$S_s - 5$	41.57 ± 5.83	43.60 ± 7.41	477.73 ± 78.47	65.46±10.44	80.28±12.81	460.71±73.63	1.032±0.165	0.380±0.061
$S_s - 6$	40.69 ± 5.81	40.99 ± 7.46	331.99 ± 75.93	57.40±10.36	70.40±12.70	401.32±72.97	0.902±0.164	0.337±0.060
$S_s - 7$	45.65 ± 5.89	45.92 ± 7.45	293.81 ± 75.36	61.08±10.36	74.91±12.71	425.26±73.01	0.959±0.164	0.362±0.060
$S_s - 8$	31.21 ± 5.52	52.74 ± 7.65	406.03 ± 77.15	63.21±10.39	77.52±12.74	444.39±73.26	1.006±0.165	0.372±0.060
$S_s - 9$	38.80 ± 5.73	44.49 ± 7.48	335.89 ± 75.99	58.80±10.33	72.12±12.67	411.33±72.83	0.927±0.164	0.346±0.060
$S_s - 10$	42.37 ± 5.92	43.51 ± 7.41	416.94 ± 77.34	63.24±10.44	77.56±12.80	443.71±73.55	0.996±0.165	0.369±0.061
$S_s - 11$	39.55±5.81	48.64 ± 7.51	353.03 ± 76.26	62.37±10.40	76.49±12.75	436.38±73.29	0.985±0.165	0.368±0.061
$S_s - 12$	25.66 ± 5.48	30.01 ± 7.23	360.05 ± 76.37	45.00±10.08	55.18±12.37	317.79±71.14	0.711±0.160	0.260±0.059
$S_s - 13$	40.58 ± 5.82	47.19 ± 7.51	533.06 ± 79.58	69.48±10.54	85.21±12.93	490.03±74.36	1.098±0.167	0.403±0.061
$S_s - 14$	38.28 ± 5.72	49.05 ± 7.59	637.49 ± 81.88	73.89±10.64	90.62±13.05	523.49±75.11	1.171±0.169	0.425±0.062
$S_s - 15$	42.24 ± 5.86	56.57 ± 7.69	434.86 ± 77.66	71.82±10.59	88.08±12.99	503.53±74.64	1.137±0.168	0.423±0.062
$S_s - 16$	43.15 ± 5.89	48.06 ± 7.47	379.53 ± 76.69	64.79±10.43	79.46±12.79	453.40±73.51	1.021±0.165	0.381±0.061
$S_s - 17$	39.18 ± 5.81	42.29 ± 7.38	464.48 ± 78.22	63.01±10.40	77.28±12.76	443.69±73.36	0.994±0.165	0.366±0.060
$S_s - 18$	35.24 ± 5.71	38.17 ± 7.32	474.61 ± 78.41	59.13±10.33	72.51±12.67	417.47±72.86	0.933±0.164	0.341±0.060
$S_s - 19$	31.78 ± 5.66	27.12 ± 7.07	300.04 ± 75.45	43.57±10.03	53.44±12.30	305.77±70.73	0.683±0.159	0.253±0.058
$S_s - 20$	37.82 ± 5.81	42.49 ± 7.40	510.46 ± 79.12	64.42±10.45	79.01±12.82	454.76±73.73	1.017±0.165	0.372±0.061
$S_s - 21$	38.34 ± 5.79	42.82 ± 7.39	387.32 ± 76.83	59.73±10.34	73.25±12.68	419.08±72.91	0.942±0.164	0.349±0.060
Mean	**39.11±5.77**	**45.65±7.48**	**430.56±76.79**	**63.59±10.39**	**77.99±12.74**	**446.85±73.22**	**1.004±0.164**	**0.372±0.061**

Absorbed gamma-ray dose rate (D):

The absorbed dose rate typical contribution in the air comes from terrestrial radionuclides of a trace of gamma ray was discovered in a surface typical soil sample, the assessments of dose rate which depends on assessments of the activity concentrations of radionuclides, mainly ^{238}U , ^{232}Th and ^{40}K. The absorbed doserate mean values were calculated for representative soil samples in some countries as 95.5nGy/h, in India [10],37.155nGy/hinJordan [11], and 64.5±27.1 5nGy/ hin Thailand [16]. Figure 4(a) represent of the absorbed gamma-ray dose rate (D) variation of my samples of different region and figure 4(b) represent the absorbed gamma-ray dose rate (D) comparison of different countries.

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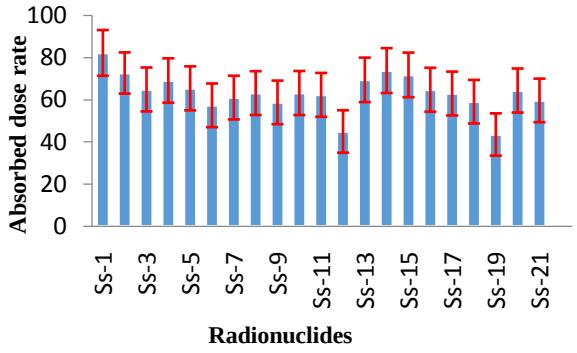

Fig. 4 (a): Compare to the absorbed dose rate of all soil samples.

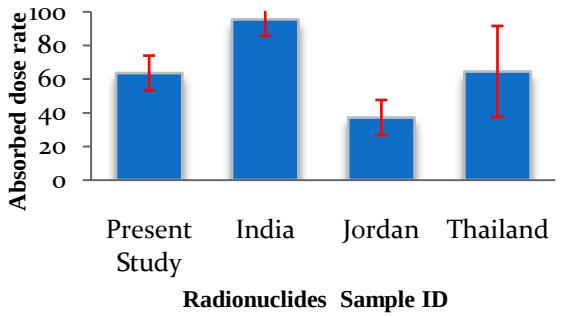

Fig. 4 (b): Compare to the absorbed dose rate of various countries.

Annual effective dose equivalent (AEDE):

The general evaluation so natural radionuclides annual effective dose equivalent hinge on the spectacular value of the absorbed dose rate in the air. The mean values of the annual effective dose identical were calculated for representative soil samples in some countries as 32.33μSv/y in Saudi Arabia [17], 152μSv/yin China [20]. Figure 5(a) represent of the annual effective dose equivalent (AEDE) variation of my samples of different region and figure 5(b) represent the annual effective dose equivalent (AEDE) comparison of different countries.

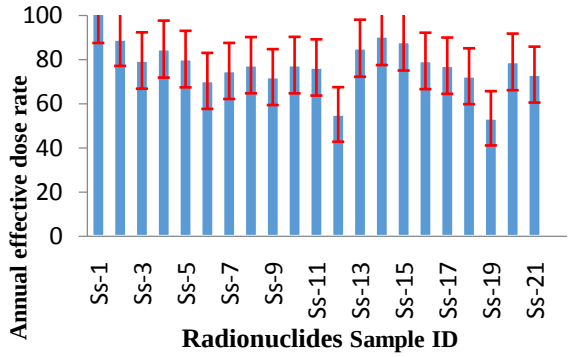

Fig. 5 (a): Compare to the Annual effective dose rate of all soil samples.

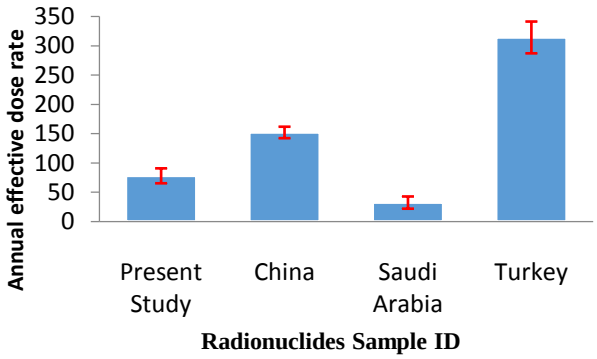

Fig. 5 (b): Compare to the Annual effective dose rate of various countries.

Annual gonadal dose equivalent (AGDE):

Natural radioactivity of the thyroid, lungs, bone marrow, bone surface cell, the gonads and the female breast is the part which involve of The UNSCEAR report. [12]. The soil samples mean values were 439.73 μSv/y for Nigeria [17], and 182.52 μSv/yfor Saudi Arabia [17]. Figure 6(a) represent of the annual gonadal dose equivalent (AGDE) variation of my samples of different region and figure 6(b) represent the annual gonadal dose equivalent (AGDE) comparison of different countries.

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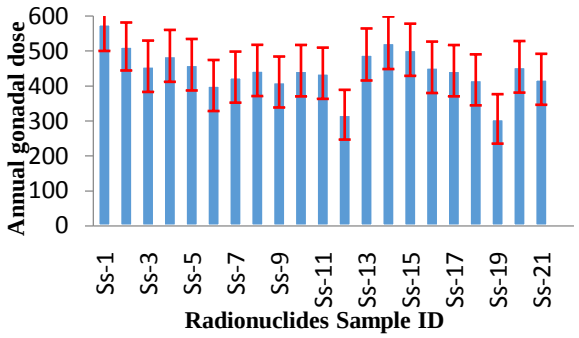

Fig. 6 (a): Compare to the annual gonadal dose of all soil samples.

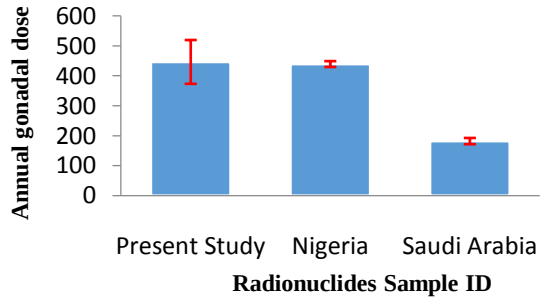

Fig. 6 (b): Compare to the annual gonadal dose of various countries.

Gamma representative level index ($I_{\gamma r}$):

The values for sediments ranged between 0.248 and 2.735 in India [19], 0.89 and 1.03 in Nigeria [18]. Figure 7(a) represent of the Gamma representative level index ($I_{\gamma r}$)variation of my samples of different region and figure 7(b) represent the Gamma representative level index ($I_{\gamma r}$)comparison of different countries.

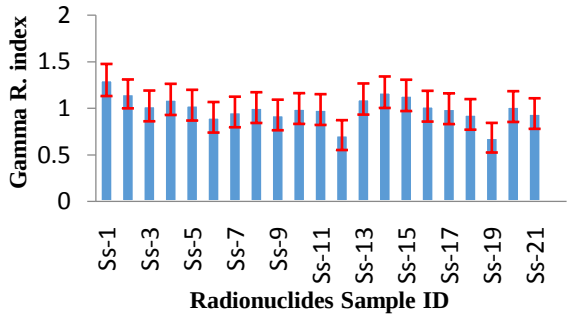

Fig. 7 (a): Compare to the Gamma Representative index of all soil samples.

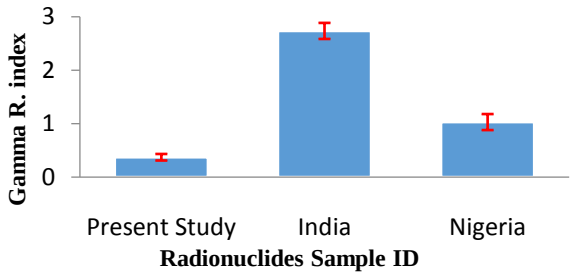

Fig. 7 (b): Compare to the Gamma Representative index of various countries.

Hazard index (Hex):

The hazard index mean values for soil samples of different countries were 0.25±0.01 for Jordan [11], 0.38±0.16 for Thailand [12], and 0.13 for Saudi Arabia [17]. Figure 8(a) represent of the hazard index (Hex)variation of my samples of different region and figure 8(b) represent the hazard index (Hex)comparison of different countries.

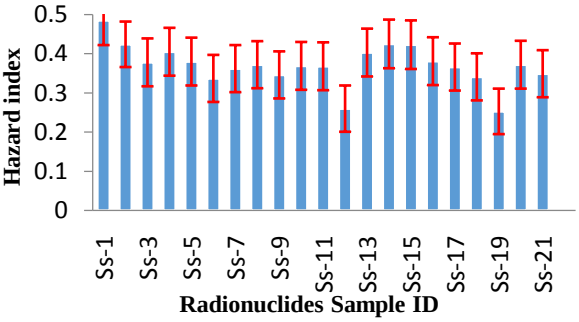

Fig. 8 (a): Compare to the Hazard index of all soil samples.

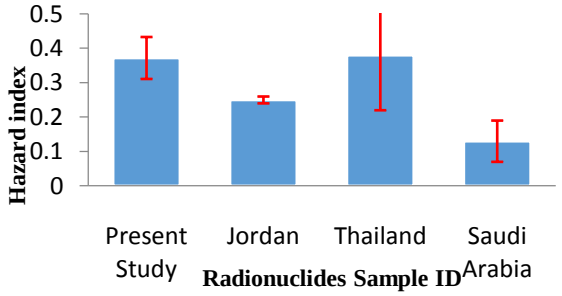

Fig. 8 (b): Compare to the Hazard index of various countries.

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4. Conclusion

The overall mean values of absorbed gamma-ray dose rate, annual effective dose equivalent, annual gonadal dose equivalent, gamma representative level index and external hazard index of natural radioactivity were measured to be 63.59±10.38nGy/h, 77.99± 12.74 μSv/ y, 446.85±73.22 μSv/y, 1.004 ± 0.164 and 0.371 ± 0.061 respectively. The acquired results in thepresent study work were compared with other results of different countries. The natural radioactivity external hazard index always less than unity, therefore no significant radiological hazard for all representative soil samples in the research area. The limit of the general effective dose for public exposure per year is set by NSRC and IAEA for Bangladesh [21]. Artificial radionuclides were not found in any representative soil samples. So the public health is not hazardous of the study area in Bangladesh. All the values of radiological doses are recommended for safety limits according to the values of different countries. The data carried on this study area of the natural and artificial radioactivity will give baseline radiometric values which help to develop future guidelines in Bangladesh for radiological protection of the flora and fauna.

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