Determination of Activity Concentrations of the Naturally Occurring Radionuclides and the dose Rates from the Samples Collected from the Chittagong Urea Fertilizer Limited (CUFL), Bangladesh

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Abstract: The activity concentrations of ^{238}U, ^{232}Th and ^{40}K have been determined for solid, liquid and product (urea) samples collected from the Chittagong Urea Fertilizer Limited (CUFL), Chittagong, Bangladesh. A total of 15 samples of different kinds were analyzed by using a calibrated high purity germanium (HpGe) detector of relative efficiency of 38%. For solid samples, the mean activity concentrations of ^{238}U, ^{232}Th and ^{40}K have been found 78.67±2.87, 59.74±2.27 and 463.71±9.16 Bq/Kg, respectively. The mean activity concentrations of product samples for the corresponding radionuclide were 73.12±2.83, 74.59±2.32 and 391.58±9.38 Bq/Kg, respectively. For the case of liquid samples, the mean activity concentrations for the same nuclides were 25.09±1.71, 11.34±1.55 and 39.59±1.49 Bq/Kg, respectively. The artificial radionuclide ^{137}Cs was not detected in any of the samples. The mean radiological hazard parameter values of outdoor absorbed dose rate, indoor absorbed dose rate, external radiation hazard, internal radiation hazard, annual effective dose equivalent, radium equivalent activity and representative level index were 95.72±9.04, 114.32±9.11 $nGyh^{-1}$, 0.530±.05, 0.7±50.05, 113.59±11.41μSvy^{-1}, 199.80±17.41 and 1.390±.14 Bq/Kg respectively, in solid samples. For the product samples, the mean values of the corresponding radiological indices were 97.10+9.71, 117.56+10.32 $nGyh^{-1}$, 0.57±0.05, 0.76±0.06, 119.50 ±11.72μSvy^{-1}, 209.50±17.72 and 1.50±0.14 Bq/Kg, respectively. Also in the liquid samples, the mean values for the corresponding radiological parameters were 18.43±2.69, 22.13±2.77 $nGy.h^{-1}$, 0.12±0.03, 0.19±0.05, 23.59± 2.36 μSvy^{1}, 43.65±3.54 and 0.32±0.03 Bq/Kg, respectively. The obtained results of this study show that for some samples the values are lower and for the remaining are higher than the World average values. The mean representative index value is less than unity which confirms that the area is safe for the factory workers and the public nearby. The results can be used as a baseline data for further researchers.

Keywords: Activity concentrations, absorbed dose, effective dose, world average values.

1. INTRODUCTION

The natural radioactivity in the environment is the main source of radiation exposure to human body which contributes through inhalation and ingestion. It comes mainly from uranium (^{238}U) series, thorium (^{232}Th) series and natural potassium (^{40}K). Since these radionuclides in soils are not uniformly distributed and vary from place to place [1, 2]. Therefore, the knowledge of their distributions in soil and rock play an important role in radiation protection and safety measurements [3, 4]. The radioactivity concentration of these nuclides above permissible level is very harmful for the human body. Therefore, a large number of scientists and non-nuclear industries have concentrated their interest for further research on natural radionuclide's that can be found in the earth's crust affecting the human and the environment. Natural radioactivity is a part of our nature surrounding us and concentrations of these radionuclide's in the environment increase with the development of technologies. Fertilizer industries such as the phosphate fertilizer industries are important sources of exposure to ionizing radiation of the people and possibly contaminating the environment.

The production process of fertilizer redistributes radionuclides throughout the environment and introduces them into final products and byproducts [5, 6]. Therefore, it is worthy of investigating the radionuclide concentrations in the final products and byproducts of the fertilizer and assess the radiological impact of fertilizer industries on the workers, public and the environment nearby. Urea fertilizer industries form an important segment of total chemicals generated itself from the factories [7]. Urea fertilizers are used in huge amounts in Bangladesh in order to grow more food to meet the increasing demand of food. There are seven urea fertilizer factories scattered all over Bangladesh involving vast area and huge manpower. Chittagong Urea Fertilizer Limited (CUFL), in Chittagong is an important installation in the country contributing significantly to the production of urea. Here the factory uses natural gas as raw materials along

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with some catalysts such as Fe_2O_3, Fe_3O_4, Al_2O_3, K_2O, CaO and SiO_2 to produce urea and these are the parts of the naturally occurring radioactive materials (NORMs) inevitably present in nature from the formation of earth [8]. Moreover, the liquid wastes generated from the production processes are discharged from the complex to the environment which finally goes to the Karnafully River and to the land adjacent to the complex. Contamination of land and water can occur either from deposition of materials originally introduced into the atmosphere or from waste products discharged directly to the ground, surface or subsurface waters from which they are eventually mobilized by ground water or erosion. Thus the wastes generated from fertilizer factories may contaminate our environment and eventually causes radiation exposure to the public. There are some reports on the presence of radioactivity in the chemical fertilizer used in Bangladesh but corresponding data on radiation exposure due to these fertilizer and the wastes generated from the fertilizer industries are still very less.

The determination of concentrations of the radionuclides would provide important information to evaluate the various pathways for the radioactive contamination to interrupt in the natural system. Therefore, the objective of the present study is to detect the radionuclides and to determine their concentration levels present in the wastes generated from the Chittagong Urea Fertilizer Limited, Chittagong, Bangladesh. It is also our aim to estimate their radiological impacts on the workers of the factory and the public nearby the plant. The data of the present work can be used as a baseline data for further research works on this line as well as it will also be helpful to create a public awareness those who are living nearby the factory.

2. MATERIALS AND METHODS

2.1. Study Area

The samples were collected from Chittagong Urea Fertilizer Limited, Anwara, Chittagong. The factory is situated at the south-eastern side of Bangladesh. The geographical location of the study area as determined by a hand held GPS set are: latitude 24º41' N and longitude 89º50' E. The factory is surrounded by the Karnofully River, sea beach and farmlands. The Karnofully River water is the main source of local irrigation. The location of this factory is shown in Figure **1**.

Figure 1: Geographical position of Chittagong Urea Fertilizer Limited (CUFL).

2.2. Sample Collection and Preparation

A total number of 15 samples namely as: clay (clarifier out, S-1 and S-2), first reformer catalyst of Ni (S-3), Waste water (Effluent out, L-5 and L-6), Boiler blow down (L-1 and L-2), Surface drain-4 (L-3 and L-4), Stream (Polisher In, L-7 and L-10) Normal water (L-8), Raw water (L-9), and final product of Urea (P-1 and P-2), were collected from Chittagong Urea Fertilizer Limited (CUFL) factory. Two other product samples of urea were collected from Jumana Urea Fertilizer Limited (JUFL, P-3 and P-4) only to compare with the CUFL data. Standard methods were followed to process the samples for characterization [9].

2.3. For Liquid Samples

Plastic pots were used to process and measure the liquid samples. At the start of the sample processing steps, the pots were made contamination-free by light hydrochloric acid solution and deionizer water. The pots were then dried using a temperature controlled oven and the weights of the empty pots were noted. The pots were then filled with liquid samples. The net weights of the samples were found from the difference of weights of sample-filled and empty pots. The pots filled with samples were then kept in the sun for several days. Finally, the pots were closed by caps, sealed tightly and wrapped with thick vinyl tape and kept for 4 weeks for achieving the secular equilibrium between gaseous and non-gaseous decay products of naturally occurring radioactive series.

2.4. For Solid Samples

The soil samples were dried in the sun for several days. The samples were then crushed and dried again in a temperature controlled oven at 100ºC for 24 hours in order to remove the moisture content in the samples. The dried samples were ground to fine powder and passed through a sieve of mesh size 200μm. The samples were then filled in cylindrical plastic containers of 6 cm diameter and 7 cm height with a volume of 180ml. The weights of all the samples were taken by an electronic balance and the net weights of the samples were noted as before. Finally, the plastic containers were closed by caps and wrapped with thick vinyl tape about their necks to seal the containers tightly. The samples were then stored for about 4 weeks to assure secular equilibrium between the ^{238}U and ^{232}Th series and their daughter's progeny.

2.5. Gamma-Ray Detection System

In γ-ray spectrometry, the full energy peak efficiency of a high purity Germanium (HpGe) detector is the number of γ-rays detected by the detector to the number of photons emitted by the source for a specific energy, is defined as:

$$\in(E)=\frac{n(E)}{A\times I_{\gamma}} \quad (1)$$

where, n(E) is the net count rate of the photo peak for the corresponding energy E, A is the present activities of the standard reference source which were calculated by using the well known decay law: $A=A_0\ e^{-\lambda t}$. I_γ is the Intensity of the gamma energy. For the determination of the efficiency of the detector (HpGe), the contributions for the coincidence summing effect and the angular correlations due to the cascading gamma-rays were taken into account followed by the literatures [10, 11]. In the present study, the International Atomic Energy Agency (IAEA) reference [9] samples RGU-1, Uranium is in silica matrix, RGTh-1: Thorium is in silica matrix and RGK-1: potassium sulphate were used for the calibration of detector efficiencies. The standard reference source has the same diameter as the soil samples of known concentrations of ^{238}U, ^{232}Th and ^{40}K radionuclides supplied by the Canada Centre for Mineral and Energy Technology (CAMET) under a contract with the IAEA [9].

2.5.1. Sample Analysis

The detection and measurement of radionuclides in the samples were carried out by gamma spectrometry system using a vertical coaxial cylindrical HpGe detector with an active volume of 172 cm^3 and a relative efficiency of 38%. The p-type HpGe detector supplied by CANBERRA (Model IGG 2020) has a resolution of 2 keV at 1332 keV of ^{60}Co. The detector was coupled to a 16 k-channel computer analyzer. The analysis was carried out using Genie 2000 software, which matched various gamma energy peaks to a library of possible radionuclides. The detector was enclosed in a cylindrical shielding container made of lead and iron with 11.3 cm thickness, 51 cm height and 28 cm internal diameter and with a fixed bottom and moving cover to reduce the external γ-ray background [12]. All the samples were counted for 50 ksec. Prior to the measurement of the samples, the gamma background at laboratory site was determined with an identical empty Marinelli beaker and plastic container

used in the sample measurement. The energy regions selected for the corresponding radionuclides were 295 and 352 keV of ^{214}Pb and 609, 1120 and 1764 keV of ^{214}Bi for ^{226}Ra, 583 and 2614 keV of ^{208}Tl, 911 and 969 keV of ^{228}Ac for ^{228}Th and 1460 keV for ^{40}K.

2.6. Calibration of HPGe Detector

In the present study, the calibration for the efficiency of the detector was performed by the International Atomic Energy Agency (IAEA) reference [9] samples of solid and liquid. The IAEA reference [9] samples are: RGU-1, Uranium is in silica matrix, RGTh-1: Thorium is in silica matrix and RGK-1: potassium sulphate. The standard reference source has the same diameter as the soil samples of known concentrations of ^{238}U, ^{232}Th and ^{40}K radionuclides supplied by the Canada Centre for Mineral and Energy Technology (CAMET) under a contract with the IAEA [9]. The detector efficiency calibration curves as a function of energy for both liquid and solid matrices have been shown in Figure **2**(**a**) and **2**(**b**), respectively.

2.7. Calculation of Activity Concentrations

The radioactivity of each sample was measured using the calibrated high purity Germanium (HpGe) Detector of energy resolution of 2.0 KeV at 1.33 MeV of ^{60}Co for a period of 20,000 s. Keeping the samples one by one on the top of the detector and counted for a period of 20,000 s. The activity concentration (A) of each radionuclide in the sample was determined by using the net count rates (N_c) after subtracting the background counts from the gross counts for the same counting time under the selected photo peaks, weight of the sample, the photo peak efficiency and the gamma intensity at a specific energy as:

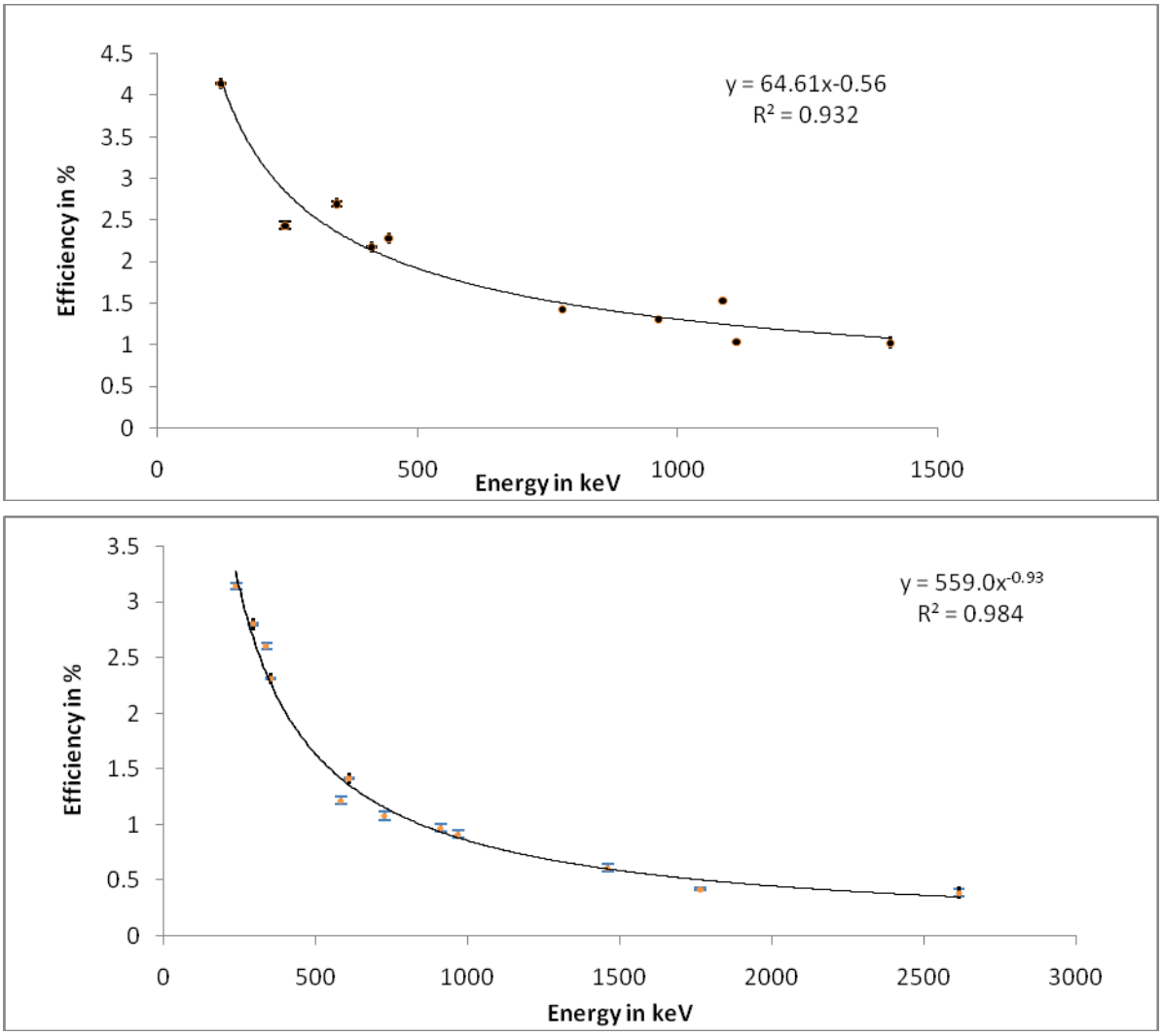

Figure 2(a): Counting efficiency curve of the HPGe Detector (For liquid standard sample). **(b):** Counting efficiency curve of the HPGe Detector.

$$A = \left(N_c \times 1000\right) / \left(\varepsilon \times I\gamma \times W\right) \quad (2)$$

Where, A = Activity concentration of the sample in Bq/. Kg Net count rate, N_c = Gross counts per second from the samples - background counts per second ε = Efficiency of the detector for the specific energy. Iγ = Intensity of the gamma ray. W = Sample weight in gm. For the analysis of peak areas of gamma spectra, a Computer software programming (GENIE 2000) was used.

2.8. Calculation of Radiation Hazard Parameters

2.8.1. Absorbed Dose Rates

The external outdoor absorbed gamma dose rates due to terrestrial γ- rays from the nuclides ^{226}Ra, ^{232}Th and ^{40}K at 1 m above the ground level was calculated as [13]:

$$D = (0.0414C_K + 0.623C_{Th} + 0.461\,C_{Ra})nGy\ h^{-1} \quad (3)$$

Where, C_K, C_{Th}, C_{Ra}, are the average activity concentrations of ^{40}K, ^{232}Th and ^{226}Ra. About 98% of the external γ dose rate from ^{238}U series is delivered by the ^{226}Ra sub series. So disequilibrium, between ^{226}Ra and ^{238}U will not affect the results of dose calculations from the measurement of ^{226}Ra.

2.8.2. Annual Effective Dose Rates

The absorbed dose rate was converted into annual effective dose equivalent by using a conversion factor of 0.7 SvGy-1 recommended by the [13] and 0.2 for the outdoor occupancy factor by considering that the people on the average, spent ~ 20% of their time in outdoors. The Effective dose due to natural activity in the soil was calculated by:

$$\begin{aligned} &Effective\ dose, E = Dose\ rate, D\left(nGyh^{-1}\right) \\ &\times 8760\left(hy^{-1}\right)\times 0.2\times 0.7SvGy^{-1}\times 10^3 \end{aligned} \quad (4)$$

2.8.3. Radium Equivalent Activity

Radionuclides of ^{232}U, ^{232}Th and ^{40}K are not homogeneously distributed in soil. The inhomogeneous distribution from these naturally occurring radionuclides is

Table 1: Activity Concentrations of ^{238}U, ^{232}Th, ^{40}K and ^{137}Cs of all kind of Samples

Sample Type	Sample ID	Activity of ^{238}U, (Bq.Kg^{-1}) with (±1σ)	Activity of ^{232}Th, (Bq.Kg^{-1}) with (±1σ)	Activity of ^{40}K, (Bq.Kg^{-1}) with (±1σ)	Activity of ^{137}Cs, (Bq.Kg^{-1}) with (±1σ)
Solid	S-1	77.04±2.84	61.85 ±2.16	520.85±10.4	ND
	S-2	72.04±2.81	52.16 ±2.12	410.96±9.41	ND
	S-3	86.94±2.91	65.21 ±2.44	459.31±7.68	ND
	Average	78.67±2.85	59.74±2.24	463.71±9.16	ND
Product Urea	P-1	72.09±2.82	73.14 ±2.25	387.90±11.3	ND
	P-2	74.12±2.83	76.03 ±2.36	395.58±7.45	ND
	Average	73.12±2.83	74.59±2.32	391.58±9.38	ND
Liquid	L-1	25.10±1.25	11.28 ±1.31	42.03±1.48	ND
	L-2	25.21±1.27	11.31 ±1.29	63.32±1.95	ND
	L-3	27.91±1.79	13.41 ±1.89	49.21±1.31	ND
	L-4	28.91±2.79	13.61 ±1.89	49.56±1.32	ND
	L-5	17.91±0.97	7.33 ±1.89	19.07±1.36	ND
	L-6	17.86±0.79	7.44 ±1.79	22.32±1.72	ND
	L-7	26.91±1.67	11.39 ±1.79	22.94±1.79	ND
	L-8	26.81±2.79	12.41 ±1.89	43.58±1.60	ND
	L-9	25.31±1.79	12.31 ±1.45	55.91±2.48	ND
	L-10	28.91±1.97	13.32 ±1.39	28.12±1.30	ND
	Average	25.09±1.71	11.34±1.55	39.59±1.49	ND
Mean for all samples		41.86±1.82	33.12±1.94	193.32± 7.84	ND

ND = Not detected.

due to disequilibrium between ^{226}Ra and its decay products. For uniformity in exposure estimates, the radionuclide concentrations have been defined in terms of radium equivalent activity (Ra_{eq}) in Bq kg^{-1}. This allows comparison of the specific activity of materials containing different amounts of ^{226}Ra, ^{232}Th and ^{40}K according to the author [5]:

$$Ra_{eq} = C_{Ra} + 1.43C_{Th} + 0.077C_K \quad (5)$$

Where, C_{Ra}, C_{Th} and C_K are the activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K in Bq kg^{-1}, respectively.

2.8.4. External Hazard Index

The external hazard index (H_{ex}) is the indoor radiation dose rate due to the external exposure to gamma radiation in construction materials of dwellings which was calculated by [5]:

$$H_{ext} = C_{Ra}/370 + C_{Th}/259 + C_K/4810 \quad (6)$$

Where, C_{Ra}, C_{Th} and C_K are the specific activities of ^{226}Ra, ^{232}Th and ^{40}K in Bq.kg^{-1}, respectively. This index value must be less than unity to the radiation hazard insignificant i.e.; the area is safe to the human for living.

2.8.5. The Representative Level Index

The formula for calculating the representative level index $I_{\gamma r}$, is as follows:

$$I_{\gamma r} = \left(C_{Ra}/150 + C_{Th}/100 + C_K/1500\right) \quad (7)$$

Where, C_{Ra}, C_{Th} and C_K are activity concentrations of ^{226}Ra, ^{232}Th, and ^{40}K, respectively.

3. RESULTS AND DISCUSSION

In the present study at Chittagong Urea Fertilizer limited (CUFL) located at Anwara, Chittagong in Bangladesh, the results can be summarized as: i) Activity concentrations and, ii) Radiological indices.

3.1. Activity Concentrations for all Studied Samples

Activity concentrations for the nuclides ^{238}U, ^{232}Th, ^{40}K and ^{137}Cs of Chittagong Urea Fertilizer limited (CUFL) samples were determined by using equation (2) and the results for the same are shown in Table **1** with the uncertainty of 1 σ level. Here, the table shows that different values of different kind of samples collected in various stages of the factory which may possible due to the variation of concentrations of the used raw materials. The results for the nuclides ^{238}U, ^{232}Th and ^{40}K for all samples are shown in Figure **3** with the world average values for the same kind of nuclides. The mean values for all collected samples of CUFL for the nuclides ^{238}U, ^{232}Th and ^{40}K are also shown in Figure **4** that shows that the obtained values for the nuclides ^{238}U and ^{232}Th are reasonably in good agreement but ^{40}K is lower compared to the world average values.

3.2. ^{238}U Activity

The range of activity concentrations for solid samples is 72.04 ± 2.81 – 86.94 ± 2.91Bq/Kg with average value of 78.67 ± 2.87Bq/Kg, for product samples 69.91 ± 2.79 – 74.31 ± 2.82 Bq/Kg with an average of 73.12 ± 2.83 and for liquid samples 17.86 ± 0.79 – 28.91 ± 1.97 Bq/Kg with average of 25.09 ± 1.71Bq/kg. The variation among different kind of samples may be due to the variation of concentrations at different stages of the factory. The mean value for all studied samples is 41.86 ± 1.82 Bq/kg which is slightly higher than the world average of 35Bq/kg (shown by the dotted line) as reported by [13].

3.3. ^{232}Th Activity

The range of activity concentrations of ^{232}Th for solid samples is found within 52.16 ± 2.12 – 65.21 ± 2.44Bq/Kg with mean of 59.74 ± 2.27Bq/Kg, for product samples 57.31 ± 1.89 – 76.03 ± 2.36 Bq/Kg with mean value of 74.59 ± 2.32 Bq/kg. For the case of liquid samples, the range is 7.33 ± 1.89 – 13.41 ± 1.89 Bq/Kg with mean value of 11.34 ± 1.55 Bq/kg. The average value for all samples of the same nuclide is 33.12 ± 1.94 Bq/Kg, which is in good agreement with the world average of 30 Bq/kg (shown by the dotted line).

3.4. ^{40}K Activity

The activity concentrations of ^{40}K is found in the range of 410.96 ± 9.41 – 520.85 ± 10.4 Bq/Kg for solid samples , for product samples 317.56 ± 9.04 – 395.58 ± 7.45 Bq/Kg, for liquid samples 19.07 ± 1.36 – 63.32 ± 1.95 Bq/Kg with mean value of 193.32 ± 7.84 Bq/kg for all samples. The mean for all samples is 193.32 ± 7.84 Bq/Kg which is smaller than the worldwide average of 400 Bq/kg (dotted line) for the same kind of nuclide.

3.5. ^{137}Cs Activity

The activity concentration of ^{137}Cs is not found in any kind of samples.

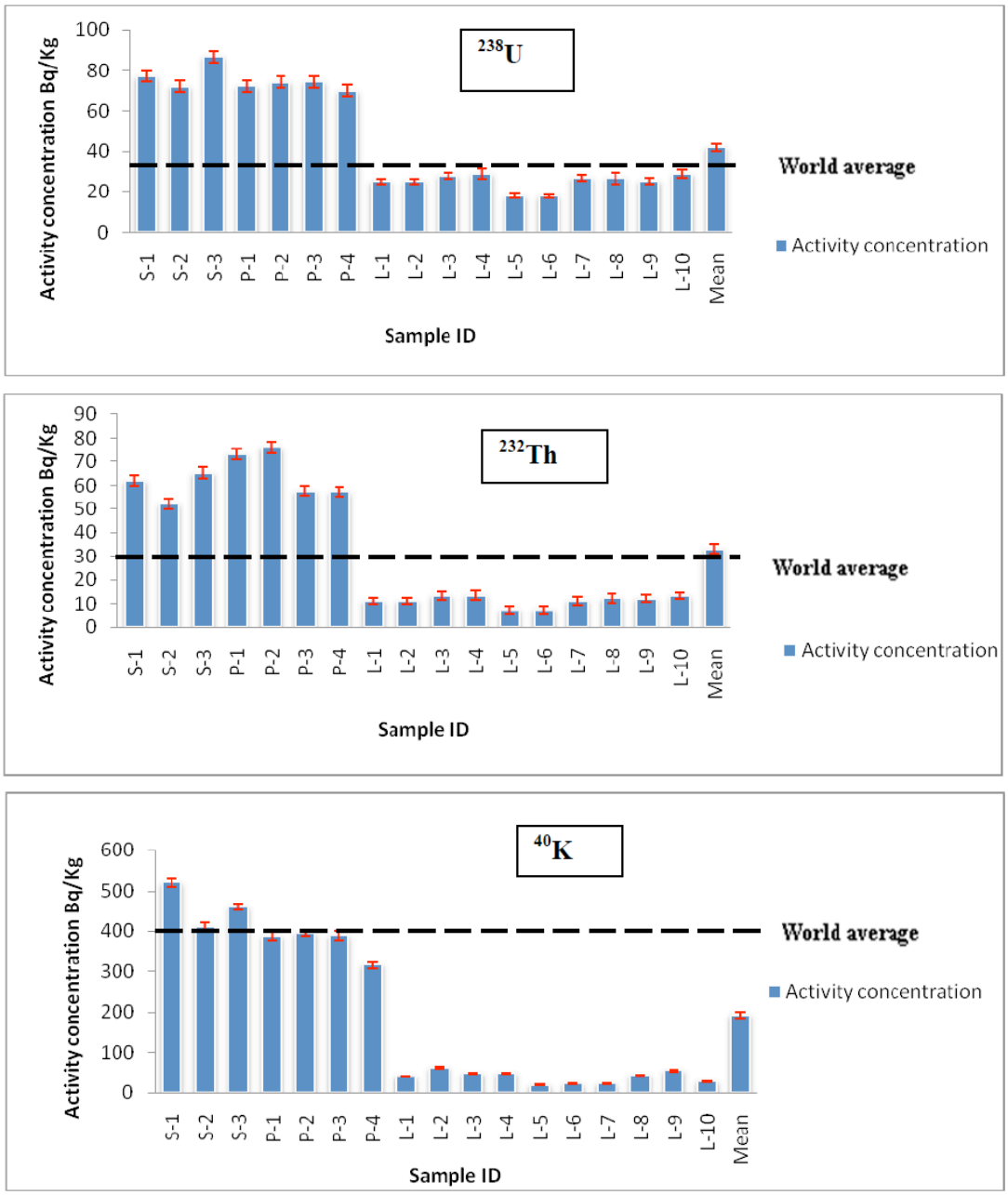

Figure 3: Activity concentrations of all samples with world average value.

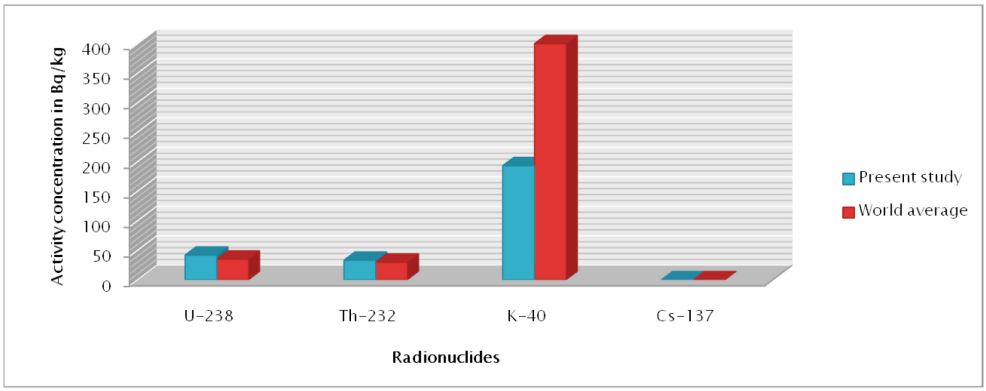

Figure 4: Mean activity concentration of all samples with world average value.

3.6. Radiological Indices

In order to assess the health effects, the radiation hazards such as absorbed dose rate (D), the external radiation hazard index ($H_{ext.}$), the annual effective dose (E), the representative level index ($I_{\gamma r}$) and the radium equivalent activity (Ra_{eq}) have been calculated from the activity of nuclides ^{226}Ra, ^{232}Th, ^{40}K using the equations (3-7), respectively and the values have been shown in Table **2**.

From Table **2**, it shows that the outdoor air absorbed dose rate due to terrestrial gamma rays at 1m above the ground were calculated for ^{232}U, ^{232}Th and ^{40}K and the range is 13.97 ± 1.37 98.83 ± 9.02 $nGyh^{-1}$ with an average of 49.23 ± 6.33 $nGyh^{-1}$ which is smaller than the world average value of 60 $nGyh^{-1}$.

The external radiation hazard is found in the range of 0.10 ± 0.03 – 0.58 ± 0.05, with the mean value of 0.36 ± 0.03 which is less than 1 and it is safe for the human in that area. The annual effective dose rates are found in the range of 16.43 ± 2.34 – 121.29 ± 11.47 μSvy^{-1} with mean value of 60.15 ± 7.11μSvy^{-1}, which is also higher than the world average value of 80μSvy^{-1}. The Indoor dose rate was not evaluated because the essential data on the average build-up of radon gas in the indoor atmosphere was not available. The representative level index is found in the range of 0.27 ± 0.02 – 1.54 ± 0.14 with mean value of 0.77 ± 0.08. The result is higher than the world average value of 0.66. The radium equivalents activity (Ra_{eq}) is found in the range of 41.43 ± 3.73 – 215.55 ± 17.76 Bq/kg, mean value of 107.89 ± 11.71 which is less than the safe limits of 370 Bq/kg as recommended by the organization for Economic Cooperation and Development (ECD).

CONCLUSION

The detection of radionuclides, their activity concentrations and radiological hazard parameters of three different kinds (solid, liquid and product) of total 15 samples from Chittagong Urea Fertilizer Limited (CUFL), Chittagong, Bangladesh, were determined as a part of assessment of the radiological impact of fertilizer industries of Bangladesh on the factory

Table 2: The Radiological Parameters for all kind of Samples

Sample Type	Sample ID	Outdoor Absorbed dose Rate (D) in $nGy.h^{-1}$	The External Radiation Hazard, H_{ext}	The Annual Effective dose Equivalent (E) (Svy^{-1})	The Representative Level Index, $I_{\gamma r}$	The Radium Equivalent Activity, Ra_{eq} ($Bq.Kg^{-1}$)
Solid	S-1	96.34±9.0	0.55±0.05	118.59±11.10	1.47±0.14	205.59±17.36
	S-2	92.10±9.07	0.48±0.04	101.27±10.98	1.27±0.14	178.27±17.18
	S-3	98.83±9.02	0.58±0.05	122.55±11.32	1.54±0.14	215.55±17.76
	Mean	95.72±9.04	0.53±0.05	113.59±11.41	1.39±0.14	199.80±17.41
Product Urea	P-1	95.97±9.63	0.56±0.04	117.70±11.30	1.47±0.14	206.70±17.30
	P-2	98.22±9.79	0.58±0.05	121.29±11.47	1.52±0.14	213.29±17.47
	Mean	97.10±9.71	0.57±0.05	119.50±11.72	1.50±0.14	209.50±17.72
Liquid	L-1	19.49±2.82	0.12±0.03	24.51± 2.48	0.31±0.03	44.48±3.97
	L-2	19.92±2.92	0.13±0.03	25.55± 2.37	0.33±0.03	44.65±3.87
	L-3	20.42±2.76	0.12±0.03	25.41± 2.45	0.34±0.03	45.34±3.49
	L-4	20.65±2.78	0.12±0.03	25.32± 2.33	0.35±0.03	45.23±3.51
	L-5	13.97±1.37	0.10±0.03	24.57± 2.32	0.27±0.02	41.67±3.62
	L-6	14.63±1.43	0.10±0.03	16.43± 2.34	0.27±0.02	41.43±3.73
	L-7	19.88±2.82	0.12±0.03	17.27± 2.35	0.33±0.03	44.77±3.81
	L-8	19.57±2.67	0.13±0.03	24.81± 2.37	0.34±0.03	44.89±3.37
	L-9	20.06±2.70	0.12±0.03	25.71± 2.27	0.33±0.02	45.66±3.89
	L-10	18.02±2.18	0.13±0.04	24.23± 2.35	0.34±0.03	45.28±3.23
	Mean	18.43±2.69	0.12±0.03	23.59± 2.36	0.32±0.03	43.65±3.54
Average for all samples		49.23±6.33	0.36 ± 0.03	60.15±7.11	0.77 ± 0.08	**107.89 ±11.71**

workers and the public nearby the industry. The detection of natural radionuclides of ^{238}U, ^{232}Th, ^{40}K and ^{137}Cs and their activity concentrations were determined by using a calibrated HpGe detector. Here there is no artificial radionuclide was found in this study. The activity concentrations and the radiological hazard parameters for all samples were determined individually. The activity concentration values for a few samples were lower and for others were higher than the world average values. The radiological hazard parameters from these samples were found within the acceptable limit set by the ICRP report which confirms that there is no radiation hazard risk for the workers of CUFL and the public nearby the industry.

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