Measurement of activity concentration levels of radionuclides and associated hazard Indices in soil samples collected from Aurangabad, Maharshtra-India

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Abstract— The activity concentrations of natural radionuclides (^{226}Ra, ^{232}Th and ^{40}K) in the soil samples collected from different area of Aurangabad, India were determined by gamma ray spectroscopy using a well calibrated NaI (Tl) detector system. The range of activity concentrations of (^{226}Ra, ^{232}Th and ^{40}K) were found to be (4.169 to 12.862, 8.658 to 21.316 and 40.088 to 130.87) Bq.kg^{-1} respectively. With an average value of 8.178, 17.408 and 96.496 Bq.kg^{-1} respectively, which are low when compared with worldwide average of 35, 30 and 400 Bq.kg^{-1}. The radium equivalent activity concentration was found in the range from 29.379 to 50.638 Bqkg^{-1}, the absorbed dose rate was found to be in the range from 13.640 to 22.825 nGyh^{-1} with an average value of 18.317 nGyh^{-1}, and the outdoor annual effective dose was found to vary from 0.017 to 0.027 mSvy^{-1}, which is below the safety limit of 1 mSv.y^{-1} as recommended by International Commission on Radiological Protection .Also, the internal and external hazard indices and gamma index were found to be less than unity, therefore the soil samples exhibit radiation well within the permissible limit and thus are safe.

Index Terms— Natural Radionuclides, Gamma Spectrometry, Activity concentration, Hazardous indices, Gamma Ray.

1 INTRODUCTION

HUMAN populations are always exposed to ionizing radiation from a number of natural sources in environment [1]. Radio activities of various materials were measured to evaluate the terrestrial gamma dose rate for indoor occupants. The natural radioactivity usually determined from ^{226}Ra, ^{232}Th, ^{40}K contents and most of the dose rate from natural radioactivity is due to members of the radioactive decay chains of ^{238}U (55.8%) and ^{232}Th (14%), along with ^{40}K (13.8%) [2]. Environmental radioactivity measurements are necessary for assessing the level of background radiation which may be due to either natural radioactivity sources of cosmic and terrestrial origin or man-made sources. The terrestrial component is due to the radioactive nuclides that are present in air, soils, rocks, building material and water in amounts that vary significantly depending on the geological and geographical features of a region [3, 4].The cosmic radiation originates from space. In addition to these natural sources, the level of background radiation in a region is also affected from man-made sources such as nuclear activities and accidents [5].

The external radiation exposure is caused mainly by the activity concentrations of natural radio- nuclides of uranium and thorium series and natural potassium. These primordial radionuclides have long half-lives, that they survived since their formation and decaying to attain the stable state and produce ionizing radiation in various degrees [6]. The study of the radioactive components in soil is a fundamental link in understanding the behavior of radioactivity on the ecosystem because these materials emit radiation by the disintegration of natural radionuclides and contribute to the total absorbed dose via ingestion, inhalation and external radiation. The assessment of radiation doses from natural radioactive sources is of particular importance as it is the largest contributor to the external dose of the world population. The world is naturally radioactive and around 90% of the human radiation exposure arises from natural sources such as cosmic radiation exposure to radon gas and terrestrial radiation [7]. The naturally occurring radionuclides present in soil include ^{228}Ra, ^{226}Ra, ^{238}U, ^{232}Th and ^{40}K [8,9,10]. Since these radionuclides are not uniformly distributed, the knowledge of their distribution in soil and rocks play an important role in radiation protection and measurement [11]. Only nuclides with half-lives comparable with the age of the earth or their corresponding decay products such as ^{238}U, ^{232}Th and ^{40}K existing in terrestrial materials are of great interest .

Measurements of natural radioactivity in soil are of great interest for many researchers throughout the world, which led to worldwide national surveys in the last two decades [12,13]. Radiation exposure can damage living cells, causing death in some of them and modifying others.

All of these spectrometric measurements indicate that the three components of the external radiation field, namely from the γ- emitting radionuclides in the ^{238}Uand ^{232}Th series and ^{40}K,made approximately equal contributions to the externally incident γ- radiations dose to individuals in typical situations both indoors and outdoors. Since 98.5% of the radiological effects of the uranium series are produced by

radium and its daughter products, the contribution from the ^{238}U and the other ^{226}Ra precursors are normally ignored [14,15]. To evaluate the terrestrial gamma dose rate for outdoor occupation it is very important to estimate the natural radioactivity levels in soils. The main objective of this work is to evaluate radiological hazard indices due to natural radioactivity associated with the soil samples by calculating the internal and external hazard indices, representative level index, absorbed dose rate and annual effective dose.

2 EXPERIMENTAL

2.1 Sample preparation

The soil samples were collected from different study area (Aurangabad-Maharashtra, India). About 1kg of the samples was collected from each location. Samples thus collected from various locations were brought to the laboratory. Organic materials, roots, vegetation, pebbles etc. If present were removed and the samples were initially sun-dried by spreading them in a tray. Samples were then dried in an oven at 110°C for complete removal of moisture . These samples were filled in plastic containers (7cm diameter and 10cm height). Sample containers were filled with 800gm of samples for uniformity depending upon the density of the sample.

These sample containers were stored for a period of 1 month before gamma spectrometric analysis so as to allow the establishment of secular equilibrium between ^{226}Ra, ^{232}Th and their respective daughter products. Estimation of ^{226}Ra, ^{232}Th and ^{40}K in the soil samples were carried out by using high resolution gamma – ray spectrometry, comprising of high efficiency NaI(Tl) detector coupled with a Multichannel Analyzer (MCA). To determine the activity concentration of various radionuclides, the spectrum was analyzed by employing simultaneous equation method (Abani, 1994). The activity was counted for sufficiently long time, to reduce the counting error. The background spectrum was recorded immediately before the sample counting to obtain net count rate. The activity concentration of ^{226}Ra were measured using the photo peaks of ^{214}Pb (295.22 , 351.93 KeV) ,^{214}Bi (609.31 ,1120 KeV) and ^{226}Ra (186.1 KeV).Activity concentration of ^{232}Th were calculated through the photo peaks of ^{228}Ac (911.2, 209.25, 338.32 KeV) and ^{208}Tl (2614, 583.19, 860.56 KeV).). The activity of ^{40}K was evaluated from the 1461 KeV photo peak. From the measured activities of ^{226}Ra, ^{232}Th and ^{40}K, following radiological calculations were done. The specific activity concentrations in (Bq kg^{-1}), of Radium, thorium and potassium are calculated using the following equation [16]:

$$A_{E,i} = \frac{NP}{t_c \cdot I_\gamma(E_\gamma) \cdot \varepsilon(E_\gamma) \cdot M} \quad (1)$$

Where: N_P is the number of counts in a given peak area corrected for background peaks of a peak at energy E_γ, t_c is the counting lifetime, I_γ (E_γ) is the number of gammas per disintegration of this nuclide for a transition at energy E_γ, ε (E_γ) is the detection efficiency at energy E_γ and M the mass in kg of the measured sample.

Table –1: Location details of collected samples from Aurangabad, Maharashtra-India showing latitude and longitude.

Sample No	Sample Location	Latitude	Longitude
1	Harsul Tank overflow	19.926436	75.329620
2	Ohar	19.946103	75.313918
3	Jatwada	19.956592	75.285846
4	Turn	19.966837	75.273615
5	Rasulpura T point	19.976981	75.268358
6	Ghodegaon	20.009619	75.261971
7	Sarai	20.019780	75.223154
8	Maratha Dhaba KBD	20.023803	75.186384
9	Takli Phata lamangaon	20.048840	75.196791
10	Mhaismal Begin	20.052340	75.188994

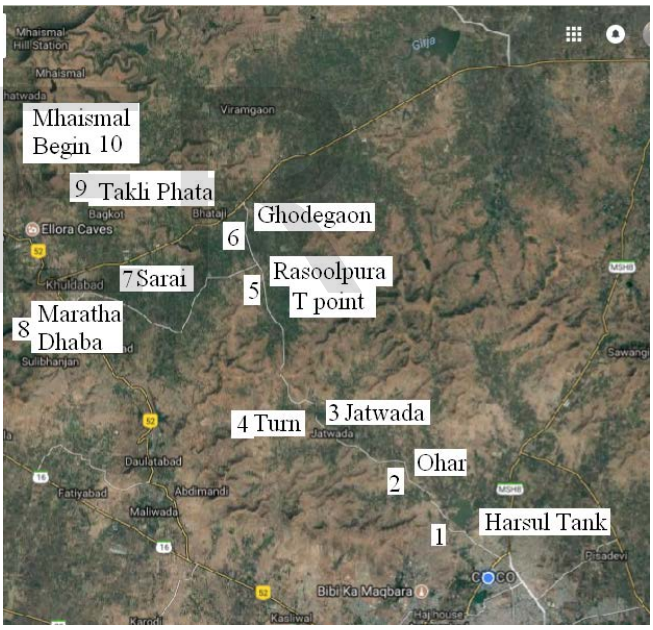

Fig-1: locations around Aurangabad where from samples are collected.

2.2 Gamma Ray Spectrometer NaI(Tl)

Gamma spectrometry offers a convenient, direct and non-destructive method for the measurement of the activity of different radionuclides in environmental samples from their characteristic gamma line in the spectrum. The scintillation gamma ray spectrometer is one of the most efficient methods for counting gamma rays and measuring their energies. The detector consists of NaI (Tl) crystal of dimension 2"x2". It has resolution (FWHM) 60KeV at 1.33 MeV of ^{60}Co and relative efficiency at 1.33MeV ^{60}Co is 8% .The detector has been coupled with Multichannel Analyzer (MCA). The NaI crystal is activated with thallium. The detector should be shielded by a minimum of 10 cm thick lead on all sides including

top to reduce the reduction of cosmic ray background by almost 98%. The spectrometer was calibrated for energy and efficiency over the photon energy range 123 to 1330 keV using IAEA standard reference radioactive sources ^{57}Co, ^{133}Ba, ^{137}Cs, ^{54}Mn, ^{22}Na and ^{60}Co .It has been procured from the Bhabha Atomic Research Centre, Mumbai which were used for calibrated energy and efficiency. The gamma lines used for calibration were: ^{214}Pb(295.22,351.93keV), ^{214}Bi(609.31,1120.29keV),^{40}K(1460keV),^{208}Tl(583.19,860.56,2614.53keV)and^{228}Ac(209.25,338.32,911.2keV).The calibration source was counted for long time to obtain clear defined photo peaks. The channel number that corresponds to the centered of each photo peaks on the MCA should be recorded and plotted graph on the X-axis is channel numbers and on the Y-axis versus the gamma ray energy. Graph is a straight line result in the plot of these data if the system is operating properly.

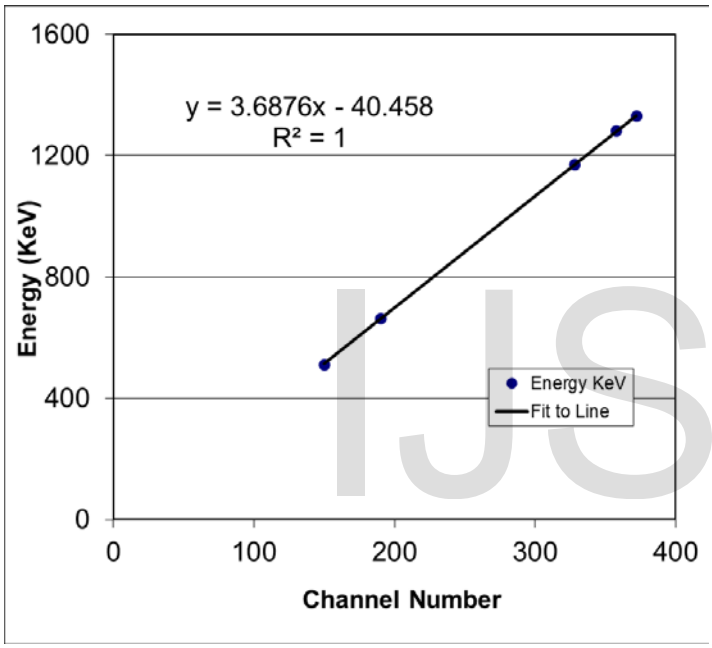

Fig-2: The energy calibration curve for radioactivity measurements in this work.

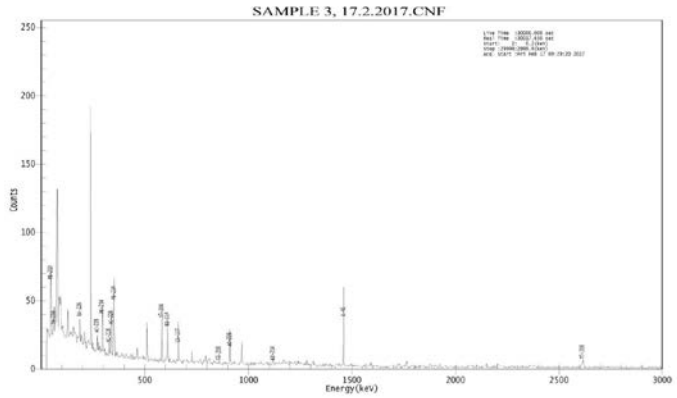

Fig-3: Gamma- ray spectrum obtained for soil sample.

A plot (2) is drawn between energy and channel number as shown above. The obtained graph is a straight line, which indicates at the gamma-ray spectrometer is linear over the entire energy range. This is a very important parameter of the spectrometer.The energy of any channel can be determined with the straight-line equation:

Energy= (m x channel number) + c

Where, c is the intercept, and m is the slope of the straight line.

3 THEORATICAL

3.1 Radium equivalent activity (Ra_{eq})

To represent the activity levels of ^{226}Ra, ^{232}Th and ^{40} K by a single quantity a common radiological index has been introduced. This index is called radium equivalent (Ra_{eq}) activity. The maximum value of radium equivalent activity (Ra_{eq}) must be less than 370Bq Kg^{-1} in order to keep the external dose less than 1.5 mSv. The distribution of ^{226}Ra, ^{232}Th and ^{40}K in soil is not uniform. Uniformity with respect to exposure to radiation has been defined in terms of radium equivalent activity (Ra_{eq}) in Bq/kg to compare the specific activity of materials containing different amounts of ^{226}Ra, ^{232}Th and ^{40}K. It was calculated through the relation [18, 19, 20]:

$$Ra_{eq} = A_{Ra} + 1.43\,A_{Th} + 0.077\,A_k \quad (2)$$

Where A_{Ra}, A_{Th} and A_K are the activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K in the soil samples in Bq/kg.

3.2 External and Internal Hazard Index

To limit the radiation exposure caused by the building materials used for construction purposes safety requirements are necessitated. The ultimate use of the measured activities in building materials is to estimate radiation dose expected to be delivered externally if a building is constructed using these materials. To limit the annual external gamma ray dose to 1.5 mSv (UNSCEAR, 2000), the external hazard index (H_{ex}) have an average value less than the acceptable value 1.5mSv. The internal exposure to ^{222}Rn and its radioactive progeny is controlled by the internal hazard index (H_{in}). For safe use of a material in the construction of dwellings (H_{in}) should be less than unity. The internal hazard index (H_{in}) should not exceed 1.0 for the unrestricted use of raw materials for building purpose [21].The external hazard index (H_{ex}) is defined by [22]:

$$Hex = \frac{A_{Ra}}{370} + \frac{A_{Th}}{259} + \frac{A_k}{4810} \quad (3)$$

The internal radiation hazard (H_{in}) was calculated using the formula [23]:

$$Hin = \frac{A_{Ra}}{185} + \frac{A_{Th}}{259} + \frac{A_k}{4810} \quad (4)$$

3.3 Gamma or level index (I_γ)

The level index I_γ of the soil is used to estimate the level of gamma radiation hazard associated with natural gamma emitters in the soil. The maximum value for I_γ corresponds to the limit of 370BqKg^{-1} for Ra_{eq}. An additional haza hazard index so called representative level index was calculate calculated by using the following formula [24]:

$$I_\gamma = \frac{A_{Ra}}{150} + \frac{A_{Th}}{100} + \frac{A_K}{1500} \quad (5)$$

3.4 Absorbed Dose rate

Activity concentration of radionuclide in soil is one of the main source of natural background radiation. The activity concentration originate from soil correspond to total absorbed dose rate in air at 1m above the ground level. The absorbed dose rate in air D(nGyh^{-1}) was calculated by using the conversion factor 0.462 nGyh^{-1}/Bqkg^{-1} for ^{226}Ra and 0.604nGyh^{-1}/Bqkg^{-1} for ^{232}Th and 0.042nGyh^{-1}/Bgkg^{-1}for ^{40}K(UNSCEAR, 2000).The absorbed dose rate (D) due to gamma radiations in air at 1m above ground level for the uniform distribution of naturally occurring nuclides was calculated using the following relation[5,25,26] :

$$Dab = 0.462\, A_{Ra} + 0.604\, A_{Th} + 0.0417\, A_k \quad (6)$$

Where A_{Ra}, A_{Th} and A_K are the activities of ^{226}Ra, ^{232} Th and ^{40}K respectively in the soil samples in Bq/kg and D is the absorbed dose rate in (nGy h^{-1}).

3.5 Annual Effective Dose

To estimate the annual effective dose, two important factors must be taken into account (i) the conversion coefficient from the absorbed dose in air to the effective dose and (ii) the indoor occupancy factor. The former gives the equivalent dose in Sv y^{-1} from absorbed dose in air Gyh^{-1} while the later gives the fraction of the time an individual is exposed to outdoor radiation. The first factor has been recommended by(UNSCER, 2000) as 0.7 SVGy^{-1} and the second factor as 0.2, which suggests that from absorbed dose in air to effective dose received by adults and considering that people , on an average, spent nearly 20% of their time outdoors, To estimate the annual effective dose rate, the conversion coefficient from absorbed dose in air to effective dose (0.7 SVGy^{-1}) and outdoor occupancy factor of (0.2) proposed by UNSCEAR 2000, were used. The annual effective dose rate in units of msv y^{-1} was calculated by the following formula:

Annual effective dose= D x (24x365) x 0.7 x 0.2 x 10^{-6} msv (7)

4 Results and Discussion

From table (2) showing the activity concentration of ^{226}Ra in the soil samples ranges from 4.169 to 12.862 Bq kg^{-1} with mean value 8.178 Bq kg^{-1} . It is seen the activities of ^{226}Ra are high in ohar soil sample comparing with other samples location. The activity concentration of ^{232}Th in the study area ranges, from 8.658 to 21.316 Bq kg^{-1} with mean value 17.408Bq kg^{-1}. Higher activity of ^{232}Th was observed in Turn soil samples. The ^{232}Th activities in Maratha Dhaba KBD - Aurangabad soil samples were found to be very low . It was observed that the activity of ^{232}Th is found higher than ^{226}Ra in all the samples. The ^{40}K activity of the soil samples vary from 40.088 to 130.871Bq kg^{-1} with mean value 96.496 Bq kg^{-1}. The activity concentration of ^{40}K is found higher than the activity of ^{226}Ra and ^{232}Th in all samples. The results shown in table (2). Also indicate that the mean value of ^{40}K > ^{232}Th > ^{226}Ra. The world average concentrations are 35, 30 and 400 Bq kg^{-1} for ^{226}Ra, ^{232}Th and ^{40}K, respectively (UNSCEAR, 2000). It is observed from table (2) the activity concentration of ^{226}Ra, ^{232}Th and ^{40}K are lower than the worldwide average. The estimated activity concentrations of the radionuclides were used to assess the radiological hazards associated with these soil by estimating the external and internal hazard index. The activity concentrations of the radionuclides are shown graphically in Fig (4).

Table-2: Activity concentration of radionuclides in soil samples collected from Aurangabad – India in (Bq.kg^{-1}).

Sample No.	Location	^{226}Ra	^{232}Th	^{40}K
1	Harsul Tank overflow	9.906	20.460	60.508
2	Ohar	12.862	20.979	100.983
3	Jatwada	8.280	19.229	120.020
4	Turn	7.470	21.316	120.142
5	Rasulpura T point	7.425	18.898	70.668
6	Ghodegaon	5.560	19.768	40.088
7	Sarai	4.169	12.010	120.061
8	Maratha Dhaba KBD	9.992	8.658	90.986
9	Takli Phata lamangaon	8.313	14.757	110.634
10	Mhaismal Begin	7.807	18.007	130.871
Minimum		4.169	8.658	40.088
Maximum		12.862	21.316	130.871
Mean		8.178	17.408	96.496

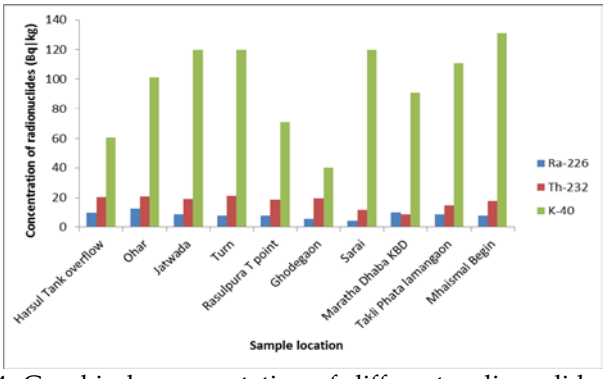

Fig-4: Graphical representation of different radionuclide concentration in soil samples collected from the study area.

Table-3: Radium equivalent activity, Radiological Hazard parameters, absorbed dose in air and annual ef-

fective dose for the soil samples collected from the study area.

Sample No	Sample Location	Radium Equivalent (Bq Kg^{-1})	Internal Hazard index	External Hazard index
1	Harsul Tank	43.8229	0.1451	0.1184
2	Ohar	50.6377	0.1715	0.1368
3	Jatwada	45.0190	0.1439	0.1216
4	Turn	47.2028	0.1477	0.1275
5	Rasulpura	39.8906	0.1278	0.1077
6	Ghodegaon	36.9150	0.1147	0.0997
7	Sarai	30.5880	0.0939	0.0826
8	Maratha	29.3789	0.1064	0.0794
9	Takli Phata	37.9343	0.1249	0.1025
10	Mhaismal	43.6341	0.1389	0.1178
Minimum		29.3789	0.0939	0.0794
Maximum		50.6377	0.1715	0.1368
Mean		40.5023	0.1315	0.1094

Sample No	Sample Location	Gamma index	Absorbed dose ($nGyh^{-1}$)	Annual effective Dose (mSv)
1	Harsul Tank	0.3109	19.4576	0.0239
2	Ohar	0.3629	22.8246	0.0270
3	Jatwada	0.3275	20.4445	0.0251
4	Turn	0.3431	21.3359	0.0262
5	Rasulpura	0.2856	17.7916	0.0218
6	Ghodegaon	0.2615	16.1803	0.0198
7	Sarai	0.2279	14.1867	0.0174
8	Maratha	0.2139	13.6399	0.0167
9	Takli Phata	0.2768	17.3673	0.0213
10	Mhaismal	0.3194	19.9404	0.0245
Minimum		0.2139	13.6399	0.0167
Maximum		0.3629	22.8246	0.0270
Mean		0.2929	18.3169	0.0224

Table (3) gives radium equivalent activity, external hazard index, internal hazard index, gamma or level index ,Absorbed dose in air and annual effective dose in soil samples collected from the study area. from the activity concentrations of ^{226}Ra , ^{232}Th and ^{40}K of the collected soil samples, the radium equivalent activity is calculated and the results are presented in Table (3). The calculated value of the radium equivalent activity ranged from 29.3789 to 50.6377 Bq/kg with average value 40.5023 Bq/kg, which is very much lower than the safe limit (370 Bq/kg) recommended by Organization for Economic Cooperation and Development [17].

The calculated values of external hazard index, internal hazard index and the level index are lower than the world average and the recommended safe limit. The external hazard index ranges from 0.0794 to 0.1368 with mean value 0.1094 and the internal hazard index ranges from 0.0939 to 0.1715 with mean value 0.1315. It is observed the mean value of internal hazard index is greater than the external hazard index. The level index ranges from 0.2139 to 0.3629 with mean value 0.2929. The calculated hazard parameters of all samples are very low comparing with the world average and the recommended safe limit given by OECD, 1979. The absorbed dose in air at a height of 1 m above the earth ranges from 13.6399 to 22.8246 $nGyh^{-1}$ with average value 18.3169 $nGyh^{-1}$. All values of absorbed dose rate are lower than the world average value i.e., 55 nGy h^{-1} (UNSCEAR, 1993). The annual effective dose ranges from 0.0167 to 0.0270 mSv/y with mean value 0.0224 mSv/y. The annual effective dose is found marginally below the international recommended value 1 mSv/y for the general public (UNSCEAR, 2000).

Table-4: Comparison of Activity Concentration of ^{226}Ra, ^{232}Th and ^{40}K and absorbed dose in air of present study with those in other countries as given in UNSCEAR (2000).

Country	^{226}Ra (Bq/kg)	^{232}Th (Bq/kg)	^{40}K (Bq/kg)	Absorbed dose ($nGyh^{-1}$)
Malaysia	38-94	63-110	170-430	55-130
Egypt	5-64	2-96	29-650	20-133
Japan	6-98	2-88	15-990	21-77
Thailand	11-78	7-120	7-712	2-100
Denmark	9-29	8-30	240-610	35-70
Belgium	5-50	5-50	70-900	13-80
Switzer-land	10-900	4-70	40-1000	15-120
Romania	8-60	11-75	250-1100	21-122
Germany	5-200	7-134	40-1340	4-350
Present study	4.17 - 12.86	8.66 - 21.32	40.09 - 130.87	13.64 - 22.82
World average	35	30	400	56

Table (4) presents the activity concentrations of radionuclide in soil samples of other countries. The present investigation is compared with the world wide values, it is found all the concentrations of the radionuclides ^{226}Ra, ^{232}Th and ^{40}K are lower than the world average value. The activity concentration values of the present study are compared with those obtained in other countries and is found that all the reported values are higher than the present study.

The absorbed dose in air at a height of 1m above the ground level is compared with other results obtained

from different countries where the present study are lower than all the reported values .

Correlation Study

Correlation is a statistical measure for finding the degree of relationship between two or more variables. Two variables are said to be correlated if a change in one variable leads to a change in the other variable.

Fig-5: shows the correlation between ^{226}Ra and ^{232}Th activity concentrations computed from the soil samples collected from the study area. There exists a strong or positive correlation between ^{226}Ra and ^{232}Th for the samples in all sampling places. The correlation coefficient between these two radionuclides is found to be (r = 0.188).

Fig-6: shows the correlation between Thorium and Potassium concentration in soil samples There exists a weak or negative correlation between ^{232}Th and ^{40}K for the samples in all sampling places. The correlation coefficient between these two radionuclides is found to be (r= -0.196).

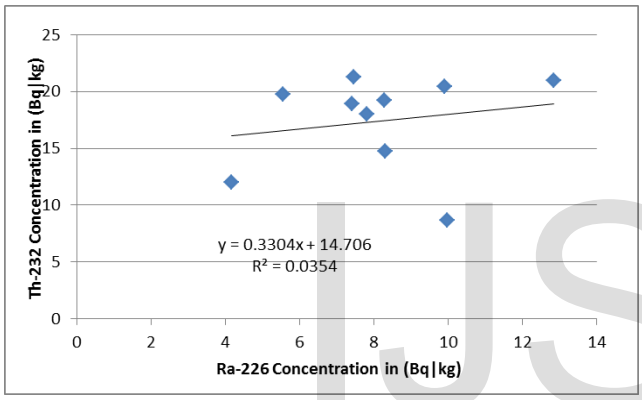

Fig-5: Correlation between ^{232}Th and ^{226}Ra activity concentrations.

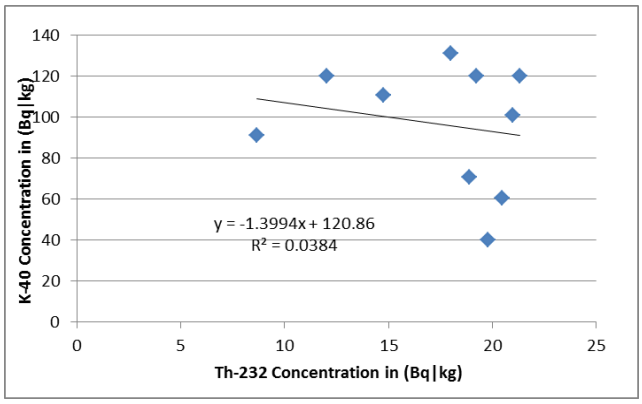

Fig-6: Correlation between^{232}Th and ^{40}K concentration in Soil samples

Fig-7: shows the correlation between Radium and Potassium concentration in soil samples There exists negative correlation between ^{226}Ra, ^{40}K [correlation coefficient r = -0.006] in soil samples. Fig (8) shows the correlation between ^{232}Th concentration and the absorbed dose in air. There exists a very good correlation between ^{232}Th and the absorbed dose in air for all the samples. The value of correlation coefficient (r = 0.832).

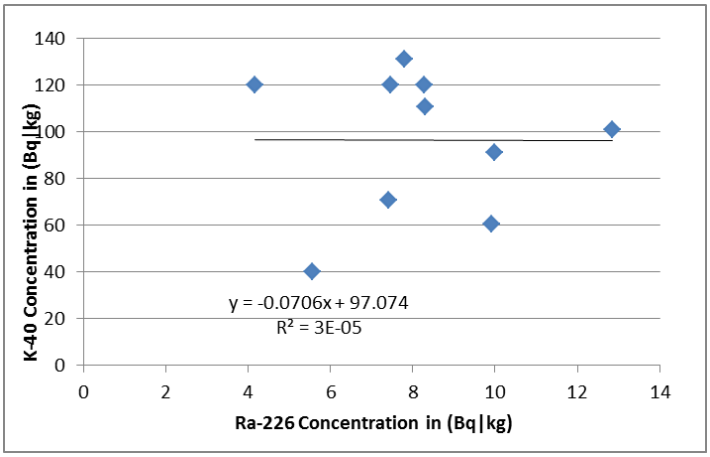

Fig-7: Correlation between Radium and Potassium concentration in Soil samples.

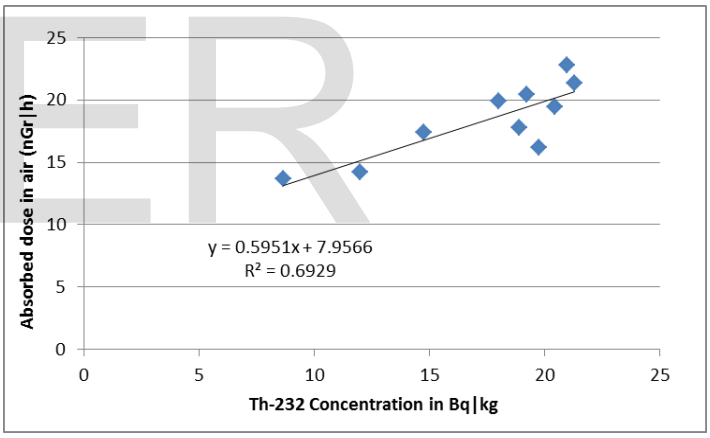

Fig-8: Correlation between absorbed dose in air and activity of ^{232}Th.

Fig (9) shows the correlation between ^{226}Ra and the absorbed dose in air. There exists a good correlation between ^{226}Ra and the absorbed dose in air. The value of correlation coefficient is (r = 0.525). Fig (10) shows the correlation between ^{40}K and the absorbed dose in air. There exists a good correlation between ^{40}K and the absorbed dose in air. The value of correlation coefficient is (r = 0.249).

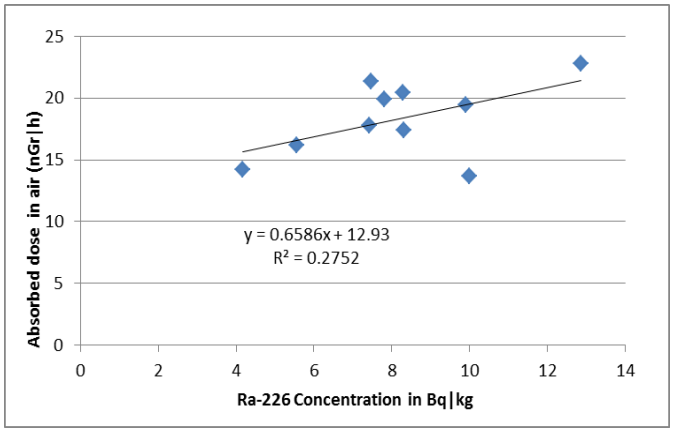

Fig-9: Correlation between Ra-226 and absorbed dose in air.

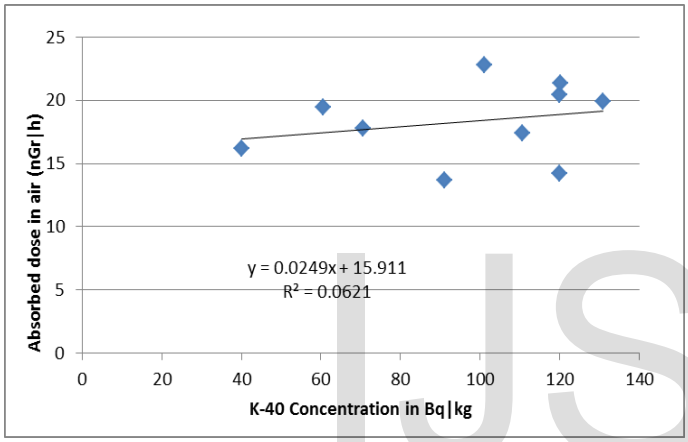

Fig-10: Correlation between K-40 and absorbed dose in air.

5 Conclusion

The activity concentrations of radionuclides ^{226}Ra, ^{232}Th and ^{40}K were measured by gamma- ray spectrometry and ranged from 4.169 to 12.862 Bqkg^{-1} for ^{226}Ra, 8.658 to 21.316B kg^{-1} for ^{232}Th and 40.088 to130.871Bqkg^{-1} for ^{40}K. The mean activity of radium, thorium and potassium is less than the world average 35 Bq kg^{-1}, 30 Bq kg^{-1} and 400Bq kg^{-1} for ^{226}Ra, ^{232}Th and ^{40}K, respectively (UNSCEAR, 2000). The Average value of radium equivalent activity is 40.5023Bqkg^{-1} which is below the recommended value of (370 Bqkg^{-1}). for each soil samples,

the radiological hazard parameters such as gamma index, external hazard index and internal hazard index have been calculated to assess the radiological hazard. It is found that all these values below the limit recommended by OECD safe levels i.e. unity. The absorbed gamma dose rate in air in the study area varied from 13.640 to 22.825 nGyh $^{-1}$ which are well below the permissible limits(56nGy h^{-1}). and the annual effective equivalent dose varied from 0.017 to 0.027 mSv y^{-1}. All the calculated parameters are lower than the recommended safe level of 1 mSv y^{-1} for the individual member of public.

The presence results of the natural radionuclides of the soil samples were compared with the soil samples measured by other countries and were found in the range below of country soil samples. These samples do not pose any health risk, since all the reported values are well below the permissible limits reported values (UNSCEAR, 2000). The soil samples used in the present study is exempted from all the restrictions concerning radioactivity, also these soil samples are safe to be used in building construction.

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