Determination of terrestrial radionuclides and related radiological risks in the soils from Pangi Valley of Chamba, Himachal Pradesh, India

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Abstract. The present study has been aimed to analyze the concentration activities of 226Ra, 232Th and 40K in soil samples collected from Pangi valley, Himachal Pradesh by means of gamma spectrometry with NaI(Tl) detector and has been found to vary between 39.61 to 79.72 Bqkg\(^{-1}\) with average of 57.66 Bqkg\(^{-1}\), 32.8 to 66.57 Bqkg\(^{-1}\) with average of 49.69 Bqkg\(^{-1}\) and 495.62 to 653.85 Bqkg\(^{-1}\) with average of 579.41 Bqkg\(^{-1}\), respectively. Radium equivalent activity in these samples has also been determined and observed lower than the maximum permissible value 370 Bqkg\(^{-1}\), acceptable for the safe use. The average absorbed dose rate in air at 1 m height from the ground level has been found 81.43 nGyh\(^{-1}\), while the average outdoor and indoor annual effective dose rate has been calculated as 0.099 and 0.40 mSvy\(^{-1}\) respectively. The estimation of excess life time cancer risk assessments suggests about 13 out of 10000 persons may get affected by carcinogenic diseases due to indoor effective dose. The calculated external and internal hazard indices have been found to be less than unity.

Keywords: Terrestrial Radionuclide’s, Gamma Spectrometry, Pangi Valley, Annual effective dose.

1. Introduction

The major determinates of background radiation exposure amongst the population are naturally occurring radionuclides in soil. Geographical arrangements and rocks that are affluent in phosphates, granites and salts contain potassium, uranium and thorium and get migrated to other places through rain water and river flows [1]. The spatial distribution of radionuclide in soil, and related external radiation exposure to public are not uniform but depend chiefly on the geological background and soil type of each section in the world [2, 3]. The plants intake these radionuclides from soils and enter the food chain of animals and humans [4]. The ingested radionuclides may get deposited in different parts of the body posing long-term radiological risks to human health and also contribute to increase in mortality rates, for instance, 40K accumulate in muscles, 238U in lungs and kidneys and 232Th in lungs, liver and skeleton tissues [5, 6]. Therefore, the analysis of soil matrices for radionuclides is significant for the estimation of radiation exposure to humans and animals and as indicators for radiological contamination in environment [7]. The investigatory study related to distribution and measurement of baseline concentrations of natural radionuclides of soils will help to assess the trait of soil, land and environment [2, 8].

Radioisotopes in soils significantly affect the terrestrial gamma radiation levels. In last decades, a number of studies have been carried out to estimate the outdoor gamma dose rate in air at 1m height from the ground level in soil. Measurement of terrestrial air absorbed dose rate is also crucial since gamma radiations provide information concerning excess life time cancer risks [2]. Although a number of research groups from India and abroad explored natural radioactivity in Himalayan region especially in Himachal Pradesh but, still the region along Pangi valley of Chamba region remained unexplored. One of the important tectonic features of the Himalaya is the Main Boundary Thrust (MBT), hence this research is
focused on this area. The aim of the present study is to analyze the soils of Pangi Valley of Chamba, Himachal Pradesh, for radiological assessment of natural radioactivity, collected data has been used to calculate the absorbed dose rate in air, annual effective dose and corresponding excess life time cancer risk from the exposure to the natural radionuclides.

2. Experimental

2.1. Study area

Pangi, administrative subdivision of Chamba district, is a narrow valley sandwiched between mighty Pirpanjal and Zanskar ranges of the Himalaya. The geographical area of Pang Valley of Chamba is 1601 Sq.kms. Geological formation of Pang Valley is similar to that of the rest of Chamba, limestone is common in the rocks and iron exists in many places. In Pang Valley, soil is more or less loam to clay loam with gravel. The principal rock formation found in the forest region of lower part of the valley from a little north of Killar, is gneissose granite. It is believed that valley is rich in minerals, mica is found in immense quantity in Dharwas area where some traces of black mica are also visible apart from the popular white one.

![Figure 1: Map represents the soil sample locations in study area.](image)

2.2. Material and methods

The soil samples have been collected arbitrarily from different nonagricultural locations close to settlements of the study area and have been marked in Figure 1. The samples have been collected after removing the foreign bulks and specks, from the top layer of the soil (6-12 cm) and packed in clean polythene bags. The samples have been dried for several weeks to eradicate the dampness and then grinded and sieved through 150 micron mesh to homogenize it. The soils have been sealed in an air tight cylindrical container and kept intact for about 4 weeks before analysis to confirm radioactive equilibrium between thorium and radium.
and their decay products and then analyzed for radioactive elements using gamma spectrometer consisting of well calibrated NaI(Tl) scintillation detector of crystal size (63 mm × 63 mm) enclosed in a thick lead shield. The spectral analysis was done by computer software SPTR-ATC (AT-1315) for time period of 3 hours. Photopeak at energy 661 keV of $^{137}$Cs is used to stabilize the gamma channel. The activity of $^{226}$Ra was determined via its daughters ($^{210}$Pb and $^{214}$Bi) through the intensity of 295.22, 351.93 keV for $^{214}$Pb gamma lines and 609.31, 1120, 1764 keV gamma lines of $^{214}$Bi, $^{232}$Th was determined from ($^{228}$Ac, $^{212}$Pb and $^{208}$Tl) through the intensity of 209, 338 and 911keV for $^{228}$Ac, 238.6 keV for $^{212}$Pb and 2610 keV for $^{208}$Tl gamma line and $^{40}$K at 1460 keV Gamma- line emitted during the decay of $^{40}$K [9, 10].

2.3. Estimation of Radiological Risks

2.3.1. Absorbed dose rate in air (ADRA).

External terrestrial gamma absorbed dose rate in air (ADRA) in nGyh$^{-1}$ at 1 m height from soil surface has been calculated from radioactivity concentrations of radionuclides in soil by using equation (1) [2].

$$\text{ADRA} = 0.461 \frac{A_{Ra}}{g^{1827}} + 0.623 \frac{A_{Th}}{g^{3019}} + 0.0414 \frac{A_{K}}{g^{3028}}$$

(1)

Here $A_{Ra}$, $A_{Th}$ and $A_{K}$ are the activity concentrations of $^{226}$Ra, $^{232}$Th and $^{40}$K in Bqkg$^{-1}$ respectively, in soil samples.

2.3.2. Annual effective dose equivalent (AEDE).

It has been evaluated by gamma absorbed dose rates in air (nGy h$^{-1}$) to study the biological effects per unit of absorbed dose that vary with the type of radiation and the organ of the body, as per the guidelines of UNSCEAR [2].

$$\text{AEDE} = D.C.F \times O.F \times \text{ADRA} \times T \times \varepsilon$$

(2)

Here AEDE is the annual effective dose equivalent (mSv y$^{-1}$), D.C.F stands for dose conversion factor (0.7 SvGy$^{-1}$), O.F signifies occupancy factor (indoor (80%) and outdoor (20%)), T represents time (8760 hours in a year) and $\varepsilon$ is a factor converting nano (10$^{-9}$) into micro (10$^{-6}$). ICRP has suggested the AEDE limit of 1 mSv y$^{-1}$ for individual [11].

Excess lifetime cancer risk (ELCR) is calculated by equation (3)

$$\text{ELCR} = \text{AEDE} \times D.L \times R.F$$

(3)

Where D.L symbolizes duration of life (70 year) and R.F is the risk factor (Sv$^{-1}$) of fatal cancer risk per sievert. For stochastic effects, ICRP suggests a value of 0.05 for the public [12].

2.3.3. Radium equivalent activity (Ra eq).

Raeq is an index calculated to estimate the gamma radiation hazard to the human beings with the use of environmental soil (like building material or agricultural purpose) that consist $^{226}$Ra, $^{232}$Th, and $^{40}$K using equation (4) [13].

$$R_{eq} = A_{Ra} + 1.43(A_{Th}) + 0.077(A_{K})$$

(4)

2.3.4. External (H$_{ex}$) and internal hazard (H$_{in}$) index.

External hazard index due to emitted gamma- rays of samples is calculated by using the equation (5).

$$H_{ex} = \frac{A_{Ra}}{370} + \frac{A_{Th}}{259} + \frac{A_{K}}{4810} \leq 1$$

(5)

In addition to external hazard, radon and its daughter products are also hazard to respiratory organ. The internal exposure due to radon and its short lived products is calculated by equation (6).

$$H_{in} = \frac{A_{Ra}}{185} + \frac{A_{Th}}{259} + \frac{A_{K}}{4810} \leq 1$$

(6)

The value of these indices must be less than unity to keep radiation hazard to be insignificant.

3. Results and discussion

World average contribution due to natural terrestrial radiations is 54nSvh$^{-1}$ [14]. The average air absorbed dose rate from the radionuclides activity concentration in soils of Pangri valley, Chamba is 81.43 nGyh$^{-1}$.
which is higher than the world average with a minimum of 63.35 nGyh\(^{-1}\) at Ranikot to a maximum of 99.21 nGyh\(^{-1}\) at location Hilour (table 1).

The variations in activity concentrations of radionuclides of soil samples of study area depend on the socioeconomic position, neighborhood environment and the differences in geological structures. Activity concentration of \(^{226}\)Ra in the soils of study area found to be varying from 39.61±9.94 in Killad to 79.48 ± 11.89 Bqkg\(^{-1}\) in the soils of Parmar Bhatori with an average value of 57.66 ± 10.15 Bqkg\(^{-1}\). The frequency distribution curve of \(^{226}\)Ra activity concentrations has been shown in Fig. 2 indicating that approximately 61% of the soil samples collected from 36 locations have \(^{226}\)Ra activity concentration lying between 39-60 Bqkg\(^{-1}\) whereas other 39% samples have the activity concentration in the range of 60.1-80 Bqkg\(^{-1}\). Activity concentrations of \(^{232}\)Th ranged from 32.8 ± 7.87 Bqkg\(^{-1}\) (at location Dehgran) to 66.57±10.20 Bqkg\(^{-1}\) (Purthi) with average of 49.69 ± 8.97 Bqkg\(^{-1}\). The frequency distribution curve of \(^{232}\)Th activity concentrations has been shown in Fig. 3 and signifies that the activity concentration of thorium ranges from 30 - 40 Bqkg\(^{-1}\) in approximately 11% samples, whereas 89% samples out of 36 samples have activity concentration in the range of 60.1-70 Bqkg\(^{-1}\).

![Figure 2. Frequency distribution of \(^{226}\)Ra in soil samples of study area.](image)

![Figure 3. Frequency distribution of \(^{232}\)Th in soil samples of study area.](image)
The average activity concentrations of $^{226}$Ra in soil samples of the study area are found to be lower than the worldwide average of 30 Bq kg$^{-1}$ [2], however comparable to other studies conducted in India [15-19]. In this study the activity concentrations of $^{226}$Ra are lower than the activity concentrations of the Pangi valley whereas $^{232}$Th activity concentrations are higher compared to the present study. For long time exposure to uranium and radium by way of inhalation have numerous health effects such as leucopenia and anemia.

The activity concentrations of $^{40}$K in soil samples vary from 495.62 ± 64.02 to 659.85 ± 82.43 Bq kg$^{-1}$ with average value of 579.41 ± Bq kg$^{-1}$, which are higher than world’s average of 400 Bq kg$^{-1}$ [2]. From Fig. 4, it is evident that only one soil sample out of 36 samples have activity concentration of $^{40}$K in the range of 400-500 Bq kg$^{-1}$ and other 35 samples have activity concentrations lying between the range of 501-660 Bq kg$^{-1}$. Soil samples from the Pangi valley of Chamba have higher concentrations of $^{40}$K compared to $^{226}$Ra and $^{232}$Th, also these values are significantly higher than the other studies conducted at different parts of India presented in (table 3) [15-18]. The higher concentrations of $^{40}$K may be due to the presence of mica rocks in the mineralogy of the study area (collection of silicate materials composed of varying amounts of potassium, iron, aluminum, and magnesium).

Outdoor and indoor annual effective dose and corresponding excess life time cancer index due to activity concentrations of these elements have been calculated and are reported in (table 2). The outdoor and indoor annual effective dose in soil samples of study area and its surrounding ranges from 0.078 to 0.12 mSv y$^{-1}$ and 0.31 to 0.49 mSv y$^{-1}$ with the average of 0.099 mSv y$^{-1}$ and 0.40 mSv y$^{-1}$ and hence seems to lie in the low High Natural Background Radiation (HNBR) area , where the annual effective dose lies below the twice of the global average of 2.4 mSv y$^{-1}$.

Excess life time cancer risk calculated from outdoor effective dose ranged from $0.15 \times 10^{-3}$ to $0.43 \times 10^{-3}$ with average of $0.35 \times 10^{-3}$, while that from indoor effective dose ranged from $1.09 \times 10^{-3}$ to $1.72 \times 10^{-3}$ and average value $1.3 \times 10^{-3}$. The results suggest that approximately 3 persons out of 10000 may be cancer affected due to the outdoor effective dose whereas about 13 persons out of 10000 may be cancer affected due to indoor effective dose. It is also found that the average of excess life time cancer risk calculated from outdoor and indoor effective dose is large as compared to the worldwide average of $0.29 \times 10^{-3}$ [2]. Since genuine statistical data of morbidity and mortality is not available, so it is difficult to evaluate the health hazards of the assessed data on the population of the area and hence this study provides data of background radiation levels for future considerations.

$^{226}$Ra in soil samples of study area has been found to vary from 133.9 Bq kg$^{-1}$ to 213.01 Bq kg$^{-1}$ with average of 172.14 Bq kg$^{-1}$. The obtained values from all location are found lower than the maximal permissible value of 370 Bq kg$^{-1}$ [20]. External hazard index ($H_e$) values for the soil samples ranges from 0.36 to 0.58 with average of 0.47 whereas the internal hazard index ($H_i$) values ranges from 0.5 to 0.84 with average of 0.62 given in (table 2) and variations at Fig.5. The values of hazard indices are less than unity for the soil samples of the study area, hence soil of the study area can be used for the construction and is safe to use and do not pose any major radiological risk to the population.
Figure 5. Variation of $H_{ex}$ and $H_{in}$ hazard index of soil samples

Table 1. Radionuclide’s activity concentrations of soil samples.

| Sr. No | Sample location        | $^{226}$Ra Bq kg$^{-1}$ | $^{232}$Th Bq kg$^{-1}$ | $^{40}$K Bq kg$^{-1}$ |
|--------|------------------------|--------------------------|-------------------------|-----------------------|
| 1      | Madhubad               | 53.92 ± 9.81             | 43.86 ± 8.53            | 590.10 ± 74.74       |
| 2      | Nakrod                 | 48.73 ± 9.86             | 46.07 ± 9.08            | 659.85 ± 82.43       |
| 3      | Shikarimod             | 46.74 ± 9.80             | 48.21 ± 9.28            | 653.98 ± 82.19       |
| 4      | Tissa                  | 45.64 ± 9.04             | 47.83 ± 8.85            | 550.02 ± 70.05       |
| 5      | Khushnagri             | 45.19 ± 9.29             | 45.14 ± 8.61            | 603.72 ± 76.23       |
| 6      | Dumas                  | 49.31 ± 9.19             | 39.68 ± 7.86            | 543.44 ± 69.32       |
| 7      | Dhiyas                 | 50.66 ± 9.77             | 36.99 ± 8.27            | 641.50 ± 80.30       |
| 8      | Dehgran                | 43.94 ± 9.30             | 32.80 ± 7.87            | 633.82 ± 79.25       |
| 9      | Baragarh               | 44.95 ± 9.32             | 45.12 ± 8.73            | 606.98 ± 76.61       |
| 10     | Devikothi              | 49.20 ± 9.61             | 51.14 ± 9.10            | 598.59 ± 75.88       |
| 11     | Ranikot                | 44.06 ± 8.59             | 36.14 ± 7.52            | 495.62 ± 64.02       |
| 12     | Kalaban                | 54.09 ± 9.61             | 47.44 ± 8.59            | 538.82 ± 69.25       |
| 13     | Sach-Pass              | 56.33 ± 10.11            | 52.86 ± 9.26            | 599.35 ± 76.08       |
| 14     | Bhagotu                | 49.19 ± 9.18             | 56.20 ± 8.86            | 546.51 ± 69.52       |
| 15     | Praygran               | 61.82 ± 10.53            | 55.01 ± 9.51            | 598.43 ± 75.35       |
| 16     | Hazel tree             | 59.52 ± 10.61            | 59.88 ± 10.11           | 639.80 ± 80.35       |
| 17     | Killad 1               | 63.88 ± 10.39            | 59.31 ± 9.47            | 537.76 ± 69.66       |
| 18     | Killad 2               | 39.61 ± 9.94             | 51.10 ± 8.76            | 520.34 ± 67.50       |
| 19     | Killad helipad         | 63.30 ± 10.51            | 41.76 ± 8.59            | 586.39 ± 74.91       |
| 20     | Hugal                  | 59.36 ± 10.34            | 46.02 ± 8.96            | 604.42 ± 76.97       |
| 21     | Manjlu                 | 57.32 ± 9.96             | 43.06 ± 8.39            | 572.37 ± 72.93       |
| 22     | Kwas                   | 61.02 ± 10.18            | 46.38 ± 8.66            | 549.87 ± 70.92       |
| 23     | Itchwas                | 57.74 ± 9.89             | 46.17 ± 8.65            | 579.33 ± 73.72       |
| 24     | Mahliat                | 61.01 ± 10.28            | 47.05 ± 8.71            | 562.31 ± 72.28       |
| 25     | Kriyuni                | 54.05 ± 9.72             | 42.32 ± 8.29            | 567.07 ± 72.33       |
| 26     | Parmar Bhatori         | 79.92 ± 11.89            | 58.78 ± 9.76            | 552.64 ± 72.63       |
| 27     | Phindroo               | 59.24 ± 10.18            | 62.34 ± 9.90            | 542.49 ± 70.29       |
| 28     | Sach                   | 67.14 ± 10.87            | 59.09 ± 9.79            | 585.91 ± 74.94       |
Table 2: Radiological hazard parameters of study area.

| Sr. No | Sample location | \(R_{eq}\) Bqkg\(^{-1}\) | absorbed dose rate in air nGyh\(^{-1}\) | Outdoor | Indoor | \(H_{ex}\) | \(H_{in}\) |
|--------|-----------------|-----------------|-----------------|---------|---------|---------|---------|
|        |                 |                 | Annual effective dose mSv\(^{-1}\) | Excess life time cancer risk \(\times 10^{-3}\) | Annual effective dose mSv\(^{-1}\) | Excess life time cancer risk \(\times 10^{-3}\) |
| 1      | Madhubad        | 162.07          | 76.61            | 0.093   | 0.33    | 0.38    | 1.33    | 0.44    | 0.58    |
| 2      | Nakrod          | 165.42          | 78.48            | 0.096   | 0.39    | 0.39    | 1.37    | 0.45    | 0.58    |
| 3      | Shikarimod      | 166.04          | 78.65            | 0.096   | 0.34    | 0.39    | 1.37    | 0.45    | 0.58    |
| 4      | Tissa           | 156.38          | 73.86            | 0.090   | 0.31    | 0.36    | 1.26    | 0.42    | 0.55    |
| 5      | Khushnagri      | 156.22          | 73.95            | 0.090   | 0.32    | 0.36    | 1.26    | 0.42    | 0.54    |
| 6      | Dumas           | 147.90          | 66.95            | 0.082   | 0.29    | 0.33    | 1.16    | 0.40    | 0.53    |
| 7      | Dhiyas          | 152.95          | 72.96            | 0.089   | 0.31    | 0.36    | 1.26    | 0.41    | 0.55    |
| 8      | Dehgran         | 139.65          | 66.93            | 0.082   | 0.29    | 0.33    | 1.16    | 0.38    | 0.50    |
| 9      | Baragarh        | 156.21          | 73.96            | 0.091   | 0.32    | 0.36    | 1.26    | 0.42    | 0.54    |
| 10     | Devikothi       | 168.42          | 79.32            | 0.091   | 0.32    | 0.39    | 1.37    | 0.45    | 0.59    |
| 11     | Ranikot         | 133.90          | 63.35            | 0.078   | 0.27    | 0.31    | 1.09    | 0.36    | 0.51    |
| 12     | Kalaban         | 163.42          | 76.80            | 0.094   | 0.33    | 0.38    | 1.09    | 0.44    | 0.59    |
| 13     | Sach-Pass       | 178.07          | 83.71            | 0.10    | 0.35    | 0.41    | 1.45    | 0.48    | 0.63    |
| 14     | Bhagotu         | 171.63          | 80.31            | 0.098   | 0.34    | 0.39    | 1.36    | 0.46    | 0.60    |
| 15     | Praygran        | 185.87          | 87.17            | 0.11    | 0.39    | 0.43    | 1.51    | 0.50    | 0.67    |
| 16     | Hazel tree      | 194.03          | 91.02            | 0.11    | 0.39    | 0.45    | 1.58    | 0.52    | 0.69    |
| 17     | Killad 1        | 190.10          | 88.66            | 0.11    | 0.39    | 0.43    | 1.51    | 0.51    | 0.69    |
| 18     | Killad 2        | 152.75          | 71.64            | 0.088   | 0.31    | 0.35    | 1.23    | 0.41    | 0.52    |
| 19     | Killad          | 168.17          | 79.47            | 0.097   | 0.34    | 0.39    | 1.37    | 0.45    | 0.63    |
| 20     | helipad         |                 |                 |         |         |         |         |         |         |
| 21     |     Hugal       | 165.99          | 81.06            | 0.099   | 0.35    | 0.40    | 1.4     | 0.46    | 0.63    |
| 22     |     Manju       | 162.97          | 76.95            | 0.094   | 0.33    | 0.38    | 1.33    | 0.44    | 0.59    |
| 23     |     Kwas        | 169.68          | 79.79            | 0.098   | 0.34    | 0.39    | 1.37    | 0.46    | 0.62    |
| 24     |     Itchwas     | 168.37          | 79.37            | 0.097   | 0.34    | 0.39    | 1.37    | 0.45    | 0.61    |
| 25     |     Mahliat     | 171.59          | 80.72            | 0.099   | 0.35    | 0.40    | 1.4     | 0.46    | 0.63    |
| 26     |     Kriyuni     | 158.23          | 74.76            | 0.090   | 0.32    | 0.37    | 1.30    | 0.43    | 0.57    |
| 27     |     Parmar      | 206.32          | 96.34            | 0.12    | 0.42    | 0.47    | 1.64    | 0.56    | 0.77    |
| 28     |     Bhatori     |                 |                 |         |         |         |         |         |         |
| 29     |     Phin droo    | 190.29          | 88.66            | 0.11    | 0.39    | 0.43    | 1.51    | 0.51    | 0.67    |
| 30     |     Sach        | 196.75          | 92.02            | 0.11    | 0.39    | 0.45    | 1.58    | 0.53    | 0.71    |
| 31     |     Hilour      | 213.01          | 99.21            | 0.12    | 0.42    | 0.49    | 1.72    | 0.58    | 0.84    |
| 32     |     Mindhal     | 169.16          | 79.90            | 0.098   | 0.34    | 0.39    | 1.37    | 0.46    | 0.61    |
### Table 3. $^{226}$Ra, $^{232}$Th and $^{40}$K activity concentrations and absorbed dose rates in various studies.

| Area                                      | $^{226}$Ra (Bq kg$^{-1}$) | $^{232}$Th (Bq kg$^{-1}$) | $^{40}$K (Bq kg$^{-1}$) | Absorbed dose rate (nGy h$^{-1}$) |
|-------------------------------------------|----------------------------|----------------------------|-------------------------|----------------------------------|
| Range                                     | Average                    | Range                      | Average                 |                                  |
| Pangi Valley of Chamba (H.P)              | 39.61 - 79.92              | 57.66                      | 49.61                   | 495.62 - 659.85                  |
| India (Hamirpur district, H.P.)           | 44.21                      | 93.10                      | 174.48                  |                                  |
| India (Himachal Pradesh)                  | 42.09 - 79.63              | 57.34                      | 82.22                   | 95.33 - 160.30                   |
| India (Punjab)                            | 25 - 42                    | 72 - 120                   | 91                      | 229 - 385                       |
| India (Karnataka)                         | BDL - 34.36                | 16.46 - 160.84             | 79.05                   | 9.72 - 933.68                   |
| India (Jammu and Kashmir)                 | 24.52                      | 41.15                      | 343                     |                                  |
| United States                             | 8 - 160                    | 4 - 130                    | 35                      | 100 - 700                        |
| China                                     | 2 - 440                    | 1 - 360                    | 41                      | 9 - 1800                         |
| Iran                                      | 8 - 85                     | 5 - 42                     | 22                      | 250 - 980                        |
| Denmark                                   | 9 - 29                     | 8 - 30                     | 19                      | 240 - 610                        |
| Worldwide                                 | 30                         | 35                         | 400                     |                                  |

**4. Conclusion**

It is essential to determine background radiations level in order to estimate the health risk. The present study determined that the average activity concentration of terrestrial radionuclides $^{226}$Ra, $^{232}$Th and $^{40}$K in soil of study area found to be 57.66 Bq kg$^{-1}$, 49.64 Bq kg$^{-1}$ and 495.62 Bq kg$^{-1}$ respectively, which is higher than the worldwide average value [2]. The results have shown that the average annual effective dose is within the range of worldwide average value 0.48 mSv [2]. The excess life time cancer risk calculated from the outdoor effective dose ranged from $0.15 \times 10^{-5}$ to $0.43 \times 10^{-3}$ with average of $0.35 \times 10^{-3}$, while that from indoor effective dose ranged from $1.09 \times 10^{-3}$ to $1.72 \times 10^{-3}$ with average of $1.3 \times 10^{-3}$. The resulting average of the excess lifetime cancer risks, which is large as compared to the worldwide average $0.29 \times 10^{-3}$. Radium equivalent activity, external (H$_{ex}$) and internal hazard index (H$_{in}$) have been found lower than the recommended limit indicating, the soil of the study area is safe and can be used for the construction and which do not pose any significant radiological threat to the dwelling population.

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