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Radionuclides Concentrations in Soils of Al-Hawija Technical Institute-Kirkuk Governate, Iraq

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Abstract: The aim of this study is to evaluate the level of natural and industrial radiation activity for soil samples of Al-Hawija Technical Institute which by using the High Purity Germanium detector (HPGe). It has been taken nine soil samples from Al-Hawija Technical Institute which located in Al-Hawija District-Kirkuk governate. The result showed that the specific activity concentration values (Bq.kg^{-1} unite) for radium ^{226}Ra, lead ^{214}Pb, lead ^{212}Pb, Actinium ^{228} Ac, Cesium ^{137}Cs and potassium ^{40}K and the calculation of the risk rates for radium equivalent 67.487 Bq.kg^{-1}, effect concentration factor 0.496, internal risk factor 0.256, external risk factor 0.182, absorbing values dose in air 32.215 nGy. kg^{-1}, internal annual effective dose values 0.158 mSv.y^{-1} annual effective external dose 0.040 mSv.y^{-1}, increased risk of cancer 0.139×10^{-3}, annual effective external dose 0.301 mSv.y^{-1} in all soil samples are lower than the average international value, so, the soils in these locals have no negative effect in human health or the environment.

Key words: Radium, radiation concentrations, High-Purity Germanium (HPGe) detector, Al-Hawija Technical Institute-Kirkuk Governorate, human health (Bq.kg^{-1} unite)

INTRODUCTION

Radiation is an effective part of our environment in which we live, since, all people will expose to it through soil, water, air and food. The radiation sources divided to two important sources, natural (cosmic radiation) and artificial radiation source that is man-made. Radiation is a natural part of the environment in which we live and everyone will expose to radiation through soil, water, air and food (Green *et al*., 1992). The radiation sources which can be divided into two important sources. The first form is the natural radiation source were found in the free nature such as the cosmic radiation coming from the stars, sun, galaxies and radiation that have existed, since, the origin of the universe. This type known radiological background radiation that includes radiation in rocks, water, soil and our bodies. The second type is the artificial radiation source which is man-made. This includes X-rays which generated by the X-ray tube or in the medical and industrial accelerators, gamma, alpha and beta rays which are all generated by nuclear reactions, neutron or photon activation and activation by charged particles, nuclear accidents, nuclear reactors, etc. (UNSCEAR., 1988). Soil pollution is generally, happened when adding or losing some or all its components which cause an imbalance, change its natural, for either the chemical or biological properties and affects directly or indirectly in those live in its surface such us humans, plants or animals. The scientific and technological progress in the manufacture of radioactive materials and their application in many field became the most risk threats the elements of environment including the soil, so, it became necessary to know the nature and dangers of these materials and how to be protect from them and circulate them safely (Selvaskarapadian *et al*., 2000). The main concept of soil pollution mainly depends on the information about transitions and accumulation away from the site of contamination. The accumulation and movement of radioactive materials depends on the interaction of materials and compounds with the solid part of the soil. This interaction reflects the soil's ability to retain and reactivate radioactive material. The physical, chemical and biological properties of the solid components can be determine their ability to retain radioactive materials. On the other hand, rainfall, irrigation

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water quantity, cultivated plant species and soil management processes largely determine the type and amount of radioactive contaminants into groundwater or their transmission to plants or other media such as air and water. In the soil, the radiation content is on the surface within 1-2 cm and 90% of the radioactive material is removed by wind and rain in the first few months of soil contamination as well as the natural degradation of radioactive material (UNEP., 2000). The aim of this study is to evaluate level of natural and industrial radiation activity for soil samples from Al-Hawija Technical Institute using the spectroscopy technique that has a high purity germanium detector. All of these process has been done, to be take the samples from the site after finishing all the military operations. As a result, this study has contributed in accounted the level of radiation in the soil taken samples from a polluted location, Al-Hawija Technical Institute. Eventually, it recorded values lower than danger numbers which allowed values as compared to the international limits.

MATERIALS AND METHODS

The theoretical side: Specific Activity concentration (A) is defined as the radiation effectiveness of the unit of mass the radioactive material. Specific activity concentration is calculated by using Eq. 1:

$$A(Bq/kg) = \frac{N}{\varepsilon(E_\gamma)\cdot I_\gamma(E_\gamma)\cdot M\cdot t} \quad (1)$$

Where:

N = The Net count under the top

•(E•) = The Efficiency of the gamma ray detector

M = The Mass of the model in kg and t is the counting time in the second unit

I• (E•) = The percentage of the potential Emission of gamma from the radionuclides under study

Radium equivalent activity (Ra_{eq}) is defined as a radiation factor used to ensure the uniform distribution of natural radionuclides represented by ^{226}Ra, ^{232}Th and ^{40}K. It is measured in $Bq.kg^{-1}$ and can be calculated by Eq. 2 (Badawy *et al*., 2015; Ramola *et al*., 2011):

$$Ra_{eq}(Bq.kg^{-1}) = A_{Ra} + 1.43\,A_{Th} + 0.077\,A_K \quad (2)$$

The A_{Ra}, A_{Th} and A_K are the radioactive effects of ^{226}Ra, ^{232}Th and ^{40}K in $Bq.kg^{-1}$, respectively. The maximum allowable value of radium equivalent is 370 $Bq.kg^{-1}$ (Tawfiq *et al*., 2015). Absorbed dose rate in air for gamma ray (D.) at mL above ground level can be calculated by using efficacy quality of ^{226}Ra, ^{232}Th and ^{40}K as in Eq. 3 (Ramola *et al*., 2011):

$$D\gamma(nGy.h^{-1}) = 0.462\,A_{Ra} + 0.604\,A_{Th} + 0.0417\,A_K \quad (3)$$

D• = The rate of Dose absorbed in A_{Ra}, A_{th}

A_K = The efficacy quality of ^{226}Ra, ^{232}Th and ^{40}K 40 in $Bq.kg^{-1}$

The Hazard guide (H) is defined as a radiation factor used to determine external and internal radiation risks. The external risk index (H_{ex}) and the internal risk index (H_{in}) are calculated by using Eq. 4 and 5 (Badawy *et al*., 2015; Tawfiq *et al*., 2015):

$$H_{ex} = A_{Ra}/370 + A_{Th}/259 + A_K/4810 \quad (4)$$

$$H_{in} = A_{Ra}/185 + A_{Th}/259 + A_K/4810 \quad (5)$$

The A_{Ra}, A_K and A_{Th} are the efficacy of radium-226 and thorium-232 and potassium-40 in Bq. kg^{-1}. The external risk index (H_{ex}) and internal risk index (H_{in}) must also be <1. Annual Effective Dose Equivalent (AEDE) is defined as a radiation factor used to know the health effects of the absorbed dose and measured in $mSv.y^{-1}$. The annual effective dose equivalent is estimated by using the conversion factor 0.7 Sv. The Gy^{-1} which converts the absorbed dose in air to the effective dose as well as using indoor occupancy factor 0.8 and outdoor occupancy factor 0.2 as in Eq. 6 and 7 (Tawfiq *et al*., 2015; Mehra *et al*., 2009):

$$AEDE_{in}(mSv.y^{-1}) = D(nGy.h^{-1})\times 10^{-6}\times 8760h.y^{-1}\times 0.7Sv.Gy^{-1}\times 0.8 \quad (6)$$

$$AEDE_{out}(mSv.y^{-1}) = D(nGy.h^{-1})\times 10^{-6}\times 8760\frac{h}{y}\times 0.7Sv.Gy^{-1}\times 0.2 \quad (7)$$

Activity concentration index is an irradiation factor that estimate the risk levels of gamma-ray associated with natural radionuclides in samples and can be calculated by Eq. 8 (Hossain *et al*., 2010; Tawfiq *et al*., 2015):

$$I_\gamma = \frac{A_{Ra}}{150} + \frac{A_{Th}}{100} + \frac{A_K}{1500} \quad (8)$$

Table 1: Demonstrate the number, symbol and the name of area which the soil sample collect (Al-Hawija Technical Institute)

No and symbol of sample	Name of area
S1	The new chancellery building
S2	The site of chicken house inside the institute
S3	The first campus
S4	Department of Electrical Technique
S5	The second campus
S6	The workshop building
S7	The sport building
S8	The first student campus
S9	The second student campus

Table 2: Specific activity concentration for all radionuclides in soil samples

	Specific activity concentrations ($Bq.kg^{-1}$)					
	^{238}U ($Bq.kg^{-1}$)		^{232}Th ($Bq.kg^{-1}$)			
No of samples	^{226}Ra	^{214}Pb	^{212}Pb	^{228}Ac	^{137}Cs ($Bq.kg^{-1}$)	^{40}K ($Bq.kg^{-1}$)
S1	23.6±4.4	11.6±0.6	11±0.6	13.6±0.8	1.4±0.1	232±6.6
S2	21.3±4.9	15±1.1	16.6±1.1	16±1.2	0.6±0.2	292±9.1
S3	31.6±4.4	14.1±1.1	16.1±0.9	14.6±0.9	0.6±0.1	284.4±6.1
S4	28.4±4.8	16.5±1.2	17.2±4.3	18.47±1.2	0.8±0.2	313.6±9.5
S5	23.6±6.1	11.4±0.7	14.4±0.6	12.4±0.8	0.8±0.2	242±6.4
S6	32±6.1	10.8±0.9	10.6±0.7	10.4±0.6	B.D.L	221±7.5
S7	25±3.9	13.4±0.7	12.2±0.6	11.8±0.9	2.6±0.2	244.6±6.4
S8	21±3.7	11.6±0.6	12.2±0.6	13.6±0.8	2.4±0.1	265±6.9
S9	38.2±6.7	15.6±1.2	16.2±0.9	16.4±1.2	0.8±0.2	252±9.1
Max	38.2±6.7	16.5±1.2	17.2±4.3	18.47±1.2	2.6±0.2	313.6±9.5
Min	21±3.7	10.8±0.9	10.6±0.7	10.4±0.6	BDL	221±7.5
Ave	27.19±4.9	13.33±0.9	14.05±1.4	14.141±0.93	1.25±0.14	260.73±7.5
Global limit (UNSCEAR., 2000a, b; Cottens, 1990)	35		30		14.8	420

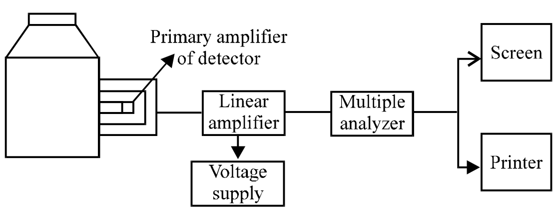

Fig. 1: Diagram for radioactive measurement system

Increasing the time or number of exposing to the radiation lead to increase the chance of happing the cancer for a specific level. This represented in the number of cancer cases happened for number of people when they expose to material for a specific level. Also ELCR can be determined form Eq. 9 if supposed the human old around 70 years (Taskin *et al*., 2009):

$$ELCR = AEDE \times DL \times RF \tag{9}$$

Since, AEDE is the annual equivalent active sample which determined from Eq. 10:

$$AEDE = AD \times 1.23 \times 10^{-3} \tag{10}$$

DL is average old of human (approximately 70 years old). RF is the dangers factor (UNSCEAR., 1993) which calculated by Sv^{-1} and probability dangers of happing of died cancer for each unit (Sv^{-1}). The back ground radiation with a low level will be generate a random effects. Since, the International Committee (ICRP 60) depends the value of 0.05 as a safe value for the general people Eq. 11:

$$\begin{aligned} EAD = &\left(0.92A_U + 1.1A_{Th} + 0.08A_K\right) \times 10^{-9} Gy.h^{-1} \times \\ &0.7Sv.Gy^{-1} \times 8760h.y^{-1} \times 0.8 \end{aligned} \tag{11}$$

Sample preparation: It has been collected nine samples of soil from nine different sites at Al-Hawija Technical Institute which all were under the occupation of ISIS and after that exposed to military operations with different types of weapons. Each sample dried then sifted, grinded well and became powder in average 0.5 kg Table 1. Sample analyzed by a high purity germanium detector (Canberra Model) in Ministry of Environment (radiation protection center) (Fig. 1, Table 2), this detector is semiconductors (p-type) which needs to reduce the temperature to -196°C by nitrogen liquid. The operating voltage is applied as a high approximately 4000 V. The

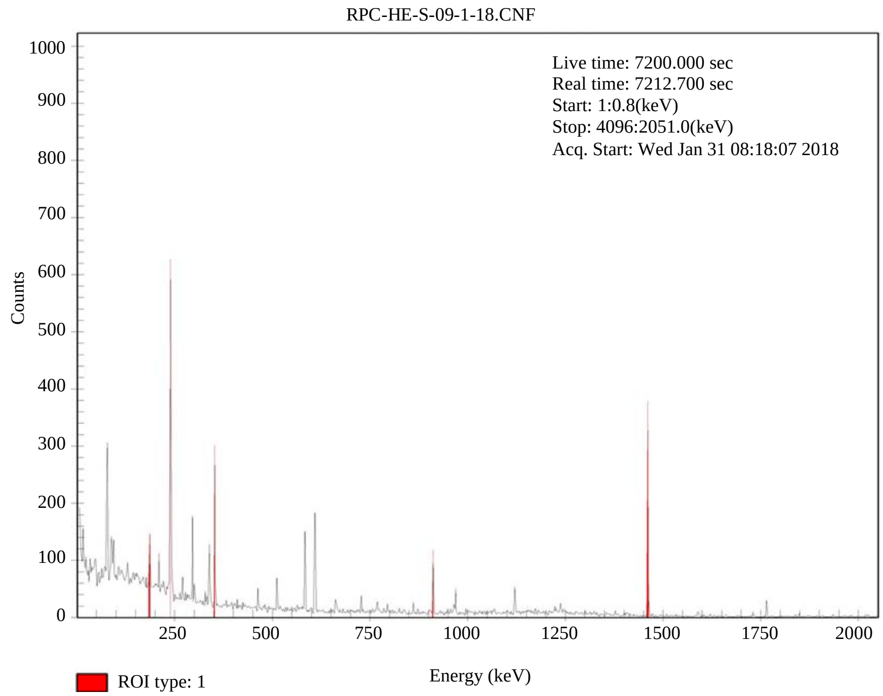

Fig. 2: The gamma radiation spectrum for soil Sample (S9)

detector was shield with lead of thickness of 10 cm and internally lined with cadmium and copper to reduce the X-ray radiation that resulted from interaction between gamma ray and lead (IAEA., 2000).The gamma radiation spectrum soil Sample (S9) explained in Fig. 2.

RESULTS AND DISCUSSION

The specific activity concentration: In Table 2 the specific activity concentration for soil samples data are summarized, the result showed highest value of specific activity for Radium ^{226}Ra 38.2±6.7 $Bg.kg^{-1}$ in Sample (S9), this value is higher than the average international value for radium (35) $Bg.kg^{-1}$ and the lowest value showed in (S8) sample 21±3.7 $Bg.kg^{-1}$. The general average was 27.19±4.9$Bg.kg^{-1}$ (Fig. 2) (UNSCEAR., 2000a, b; Cottens, 1990).

The lowest value of specific activity for ^{214}Pb in Sample (S6) was 10.8±0.9 $Bg.kg^{-1}$ while the lowest value in Sample (S4) was 16.5±1.2 $Bg.kg^{-1}$ and the average value 13.33±0.9, this value in each sample is lower than the average international value for radium 35 $Bg.kg^{-1}$ (UNSCEAR., 2000a, b; Cottens, 1990).

In Fig. 3 it can be seen that the higher and lower specific activity concentration value for Thorium series ^{232}Th in $Bg.kg^{-1}$ unite for (^{212}Pb, ^{228}Ac) in range 17.2±4.3-18.47±1.2 in Sample S4 and 10.6±0.7-10.4±0.6 in Sample S6, respectively and the average value for Thorium

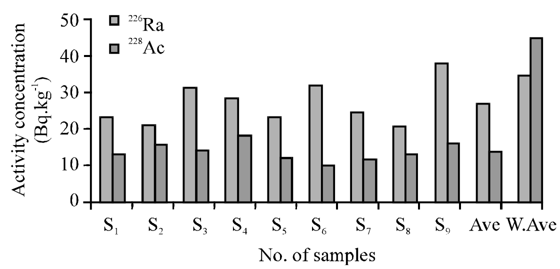

Fig. 3: Specific activity concentration for (^{266}Ra-^{228}Ac)

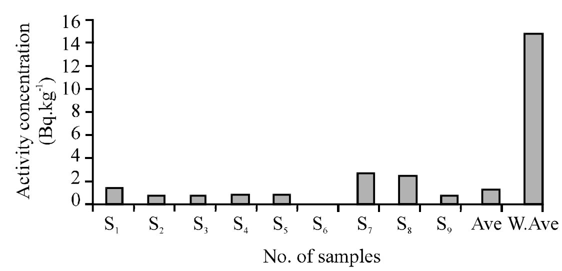

Fig. 4: Specific activity concentration for (^{137}Cs)

series ^{232}Th was 14.05±1.4-14.141±0.93, respectively, these results were lower than the average international value 30 $Bg.kg^{-1}$ (IAEA., 2000; UNSCEAR., 2000a, b). The specific activity concentration value for Cesium ^{137}Cs in soil samples were lower than the average international value 14.8 $Bg.kg^{-1}$ (UNSCEAR., 2000a, b; Cottens, 1990),

Table 3: Risk factors value for(Ra_{eq}, I_{γ}, H_{in}, H_{ex}, $AEDE_{indoor}$, $AEDE_{outdoor}$, D., ELCD, EAD)

			Hazard index		Annual effective dose (mSv .y^{-1})		Absorbed		
No. of samples	Ra_{eq}(Bq.kg^{-1})	I_{γ}	H_{ex}	H_{in}	$AEDE_{in}$	$AEDE_{out}$	dose rate (nGy.h^{-1})	ELCD *10^{-3}	EAD (mSv.y^{-1})
S1	60.912	0.448	0.165	0.228	0.142	0.036	29.023	0.125	0.271
S2	66.664	0.497	0.180	0.238	0.157	0.039	31.953	0.138	0.297
S3	74.377	0.546	0.201	0.286	0.174	0.044	35.525	0.153	0.333
S4	78.959	0.583	0.213	0.290	0.185	0.046	37.668	0.162	0.351
S5	59.966	0.443	0.162	0.226	0.141	0.035	28.695	0.124	0.268
S6	63.889	0.465	0.173	0.259	0.149	0.037	30.458	0.131	0.287
S7	60.708	0.448	0.164	0.232	0.143	0.036	29.078	0.125	0.272
S8	60.853	0.453	0.164	0.221	0.143	0.036	29.198	0.126	0.272
S9	81.056	0.587	0.219	0.322	0.188	0.047	38.341	0.165	0.360
Max	81.056	0.587	0.219	0.322	0.188	0.047	38.341	0.165	0.360
Min	59.966	0.443	0.162	0.221	0.141	0.035	28.695	0.124	0.268
Ave	67.487	0.496	0.182	0.256	0.158	0.040	32.215	0.139	0.301
Global limit (UNSCEAR., 2000a, b; Cottens, 1990)	370	0.8	1	1	0.450	0.070	55	0.2900	1.5

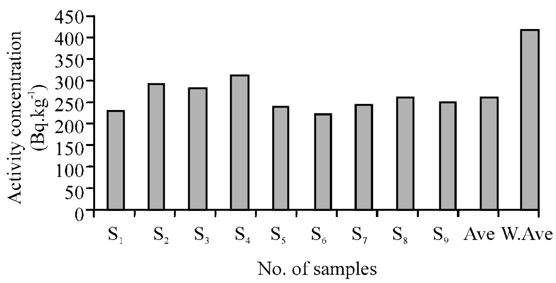

Fig. 5: Specific activity concentration for ^{40}K

the result showed lowest value in Sample (S6) was lower than detection value (B.D.L) and highest value was in Sample (S7) 2.6±0.2 Bg.kg^{-1} with average value 1.25±0.14 Bg.kg^{-1} (Fig. 4).

In Fig. 5 the specific activity concentration average value for potassium ^{40}K was lower than the average international value 420 Bg.kg^{-1} (Fig. 5), (UNSCEAR, 2000a, b; Cottens, 1990). The values were in range 221±7.53-313.6±9.5 Bg.kg^{-1} for (S4, S6), respectively.

Evaluation of radiological hazard effects for soil samples: The result showed that the average radium equivalent activity was 67.487 Bq.kg^{-1} and lower than the average international value of the radium equivalent activity recommended 370 Bq.kg^{-1} by using Eq. 2 this clearly appear in Table 3 (UNSCEAR., 2000a, b; Cottens, 1990). The average value for hazard Index gamma ray (I_{γ}) 0.496 was lower than the average international value (0.8) by using Eq. 8 (UNSCEAR., 2000a, b; Cottens, 1990). It can be seen that the average value for external and internal hazard index in soil samples were lower than the average international value (1) Bg. Kg^{-1}bu using Eq. 4 and 5), respectively, Table 3 (UNSCEAR., 2000a, b; Cottens, 1990).

The internal annual effective dose equivalent values: The internal annual effective dose equivalent values was (0.141-0.188) for (S5-S9), respectively, in average value (0.158), so, this value is lower than average international value (0.45) Table 3 (UNSCEAR., 2000a, b; Cottens, 1990). The result showed that the external annual effective dose equivalent average value 0.040 mSv.y^{-1} was lower than average international value (0.07) Table 3, mSv.y^{-1}. The average absorbed dose rate value in air for soil samples was 32.215 nGy.h^{-1} this average value was lower than average international value (55) nGy.h^{-1} Table 3 (UNSCEAR., 2000a, b; Cottens, 1990). The average value of increased incidence of lung cancer (0.139) in soil samples was lower than average international value (0.29) Table 3 (IAEA., 2000; UNSCEAR., 2000a, b). The external annual effective dose in all soil samples will be calculated, the average value was (0.301 mSv.y^{-1}) which is lower than average international value 1.5 mSv.y^{-1}, Table 3 (UNSCEAR., 2000a, b; Cottens, 1990).

CONCLUSION

In this study, the activity of the radiation has been measured both of the natural and industrial radiation in a different samples collected from the site of Al-Hawija Technical Institute. This study has been investigated by using HPGe detector have been obtained different points of conclusion.

The specific activity concentration values for (^{40}K, ^{137}Cs, ^{228}Ac, ^{212}Pb, ^{214}Pb, ^{226}Ra) in all the soil samples from Al-Hawija Technical Institute-Kirkuk Governorate were lower than the average international value. The average effects of the dangerous values which represented by the activity of the equivalent Radium (Ra_{eq}) (67.487 Bq.Kg^{-1}). While the dangerous guide of gama ray (I_{γ}) (0.469). And The guide of the internal dangerous (H_{in}) and external (H_{ex}) (0.182), (0.256) , respectively. Whenever, the annual active injection for the internal exposing ($AEDE_{out}$) (0.040) $mSv.y^{-1}$ while the annual active injection for the outer exposing ($AEDE_{in}$) (0.158 $mSv.y^{-1}$) and the average injection absorbed by air (D.) (32.215 $nGy.n^{-1}$). Also, increasing the time of exposing for radiation leads to happening the cancer (ELCR) (0.139). Since, the annual external active injection (EAD) (0.301 $mSv.y^{-1}$). In the sample of the soil is lower than the international limits.

REFERENCES

Badawy, W.M., S.U. El-kameesy, N.F. Soliman, H.S. Eissa and A.W. Mahmoud, 2015. Natural radioactivity and the associated dose from the terrestrial ecosystem of Ismailia Canal, Egypt. Intl. J. Adv. Res., 3: 768-778.

Cottens, E., 1990. Actions against radon at the international level. Proceedings of the International Symposium on SRBII, January 17, 1990, Royal Society of Engineers and Industrial of Belgium, Brussels, Belgium, pp: 1-17.

Green, B.M.R., P.R. Lomas and M.C. O'Riordan, 1992. Radon in dwellings in England. Master Thesis, National Radiological Protection, Board, Chilton, UK.

Hossain, M.K., S.M. Hossain and A.M.H. Meaze, 2010. Assessment of radiological contamination of soils due to shipbreaking using HPGe digital gamma-ray spectrometry system. J. Environ. Prot., 1: 10-14.

IAEA., 2000. Generic procedures for monitoring in a nuclear or radiological emergency. International Atomic Energy Agency (IAEA), Vienna, Austria. https://www.iaea.org/ru/publications/6260/generic-procedures-for-monitoring-in-a-nuclear-or-radiological-emergency-russian-version

Mehra, R., S. Singh and K. Singh, 2009. Analysis of 226Ra, 232Th and 40K in soil samples for the assessment of the average effective dose. Indian J. Phys., 83: 1031-1037.

Ramola, R.C., V.M. Choubey, G. Prasad, G.S. Gusain and Z. Tosheva *et al*., 2011. Radionuclide analysis in the soil of Kumaun Himalaya, India, using gamma ray spectrometry. Curr. Sci., 100: 906-914.

Selvaskarapadian, S., R. Silvakumar and N.M. Manikandan, 2000. Natural radionuclide distribution in soils of Gudalore, India. Applied Radia Isot., 52: 299-306.

Taskin, H., M. Karavus, P. Ay, A. Topuzoglu and S. Hidiroglu *et al*., 2009. Radionuclide concentrations in soil and lifetime cancer risk due to gamma radioactivity in Kirklareli, Turkey. J. Environ. Radioact., 100: 49-53.

Tawfiq, N.F., H.L. Mansour and M.S. Karim, 2015. Natural radioactivity in soil samples for selected regions in Baghdad governorate. Int. J. Recent Res. Rev., 8: 1-7.

UNEP., 2000. Depleted uranium in Kosovo, post-conflict environment assessment. United Nations Environment Programme, ?Nairobi?, Kenya. https://www.unenvironment.org/resources/report/depleted-uranium-kosovo-post-conflict-environmental-assessment

UNSCEAR, 2000a. Sources and Effects of Ionizing Radiation. United Nations Scientific Committee on the Effect of Atomic Radiation United Nations, New York.

UNSCEAR., 1988. Sources, Effects and Risks of Ionizing Radiation. United Nation Scientific Committee on the Effects of Atomic Radiation, New York, USA., ISBN:92-1-142143-8, Pages: 647.

UNSCEAR., 1993. United nations scientific committee on the effects of atomic radiation. Ionizing Radiation: Sources and Effects of Ionizing Radiation, New York, USA.

UNSCEAR., 2000b. Sources and Effects of Ionizing Radiation: Sources. United Nations Publications, New York, USA., ISBN:92-1-142238-8, Pages: 657.