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Determination of natural radioactivity by gamma spectroscopy in Balad soil, Iraq

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ABSTRACT

The specific activity of naturally and man_maderadionuclides in soil was measured in 30 different locations in Balad city, Salahadeen Governorate, Iraq. The mean of these specific activities of Bi^{214},Ac^{228},$K^{40}$and Cs^{137} in soil were found to be 0-5.2234,0-8.7271,101-1216.83,0-1.4320 Bq.kg^{-1} respectively. The radium equivalent activity was calculated and it was range from 107.788 Bg/kg to 1219.472 Bg/kg. The absorbed dose rate in air was also calculated for the samples and its range from 6.949nGyh^{-1} to 51.526nGyh^{-1}. The outdoor annual effective doses ranged from 0.0085mSv to 0.06319mSv with an average value of 0.0215mSv and the indoor annual effective doses ranged from 0.0340mSv to 0.2601mSv with an average value 0.0861mSv for one year. The external and internal hazard indices were found to be less than 1, indicating a low dose. The excess lifetime cancer risk was calculated using the risk factors of International Commission on Radiological Protection and Biological Effects of Ionizing Radiation. Thus, the values obtained when compared with their corresponding world permissible values, were found to be below the standard limits.

INTRODUCTION

The chemical composition of soil is a mixture of solid materials, air, water and organic matter which reflects the geological formation of the area. The specific activity of radio element and heavy metals in soil largely depends upon the geological formation and mineralization in the troposphere. Distribution of radionuclide in soil is of great concern as their geochemical mobility allows them to move easily and contaminates different components of the environment. Due to weathering, sedimentation and chemical interaction in the earth crust, the primordial radionuclides are found in varying concentrations in soil. At background concentrations, the naturally occurring radionuclides in the uranium, actinium, and thorium series contribute about one-half of the natural background external radiation [1]. Gamma radiation emitted from naturally occurring radioactive materials existing in all soils is responsible for the majority of internal and external exposure to the human body [2]. It has been estimated that approximately 85% of the radiation dose received by humans arises from the natural environment [3]. The levels of these doses have been observed to increase due certain anthropogenic activities [4].The growing need to safety and protect population from radiation exposure increase the importance of health physics. Studies on the radionuclides distribution in the environment and its correspondence dose can be useful as radiological baseline information that is essential in establishing rules and regulations related to radiation protection.

In order to obtain a reference data for the natural environmental radioactivity and the associated exposure in the world, many studies were carried out in many parts and in different geological formations (Karahan and Bayulken, 2000[5]; Matiullah et al., 2004[6]; Tzortzis and Tsertos, 2004[7]; Patra et al., 2006[8]; Veiga et al., 2006[9]; Kessaratikoon and Awaekechi, 2008[10]; Dimovska et al., 2011[11]).

The aim of the present study are assessing the specific activities and examines some of the radiation hazard indices of these naturally occurring radionuclides (^{228}Ac,^{214}Bi and^{40}K) in 30 samples of soil from Balad city in Salahaldeen, Iraq using γ-ray spectrometry.

Radium equivalent activity (Raeq)

The radium equivalent activity, Raeq[12,13] was calculated according to Eq. (1). The radium equivalent concept allows a single index or number to describe the gamma output from different mixtures of uranium, thorium, and^{40}K in sediments samples from different locations.

$$\mathrm{Raeq} = A_U + 1.43A_{Th} + 0.07A_K \tag{1}$$

Where A_U, A_{Th} and A_K are the specific activity of^{238}U,^{232}Th and^{40}K (Bq kg^{-1}), respectively. It has been assumed here that 370 Bq kg^{-1} of ^{238}U or259 Bq kg^{-1}of ^{232}Th or 4810 Bq kg^{-1}of^{40}K produce the same gamma dose rate. Raeq is related to the external-dose and internal dose due to radon and its daughters.

Evaluation of radiological hazard effects

Absorbed gamma dose rate (DR)

The absorbed gamma dose rates due to gamma radiations in air at 1 m above the ground surface for the uniform distribution of the naturally occurring radionuclides (^{238}U,^{232}Th and^{40}K) were calculated which based on the guidelines provided by UNSCEAR [14].The conversion factors used to compute the absorbed gamma dose rate (DR) in air per unit specific activity in Bq kg^{-1}(dry weight) corresponds to0.462 nGy h^{-1}for^{238}U, 0.604 nGy h^{-1}for^{232}Th and0.042 nGy h^{-1}for^{40}K. Therefore DR can be calculated as follows:

$$\mathrm{DR}(\mathrm{nGy\ h^{-1}}) = 0.462A_U + 0.604\ A_{Th} + 0.042A_K (2)$$

Annual Effective Doses Equivalent

Annual estimated average effective dose equivalent received by member was calculated using factor of 0.7 SvGy^{-1}, which was used to convert the absorbed dose rate to human effective dose equivalent with an outdoor of 20% and 80% for indoor [15]. The annual effective doses equivalent outdoor and indoor calculated using Eqs.3 and 4:

$$\mathrm{Outdoor\ (mSv/y)} = \mathrm{AD\ (nGyh^{-1})} \times 8760\mathrm{h} \times 0.2 \times 0.7\ \mathrm{SvGy^{-1}} \times 10^{-6} \tag{3}$$

$$\mathrm{Indoor\ (mSv/y)} = \mathrm{AD\ (nGyh^{-1})} \times 8760\ \mathrm{h} \times 0.8 \times 0.7\ \mathrm{SvGy\text{-}^{1}} \times 10^{-6} \tag{4}$$

Radiation hazard indices

Beretka and Mathew [15] defined two other indices that represent external and internal radiation hazards. The external and internal hazard index is obtained from Raeq expression through the supposition that its allowed maximum value (equal to unity) corresponds to the upper limit of Raeq(370 Bq kg^{-1}). The external hazard index(*H*ex) and internal hazard index (*H*in) can then be defined as :

$$H_{ex} = \frac{A_U}{370\ Bq/kg} + \frac{A_{Th}}{259\ Bq/kg} + \frac{A_K}{4810 Bq/kg} \tag{5}$$

$$H_{in} = \frac{A_U}{185\ Bq/kg} + \frac{A_{Th}}{259\ Bq/kg} + \frac{A_K}{4810 Bq/kg} \tag{6}$$

This index value must be less than unity in order to keep the radiation hazard to be insignificant.

Excess Lifetime Cancer Risk (ELCR)

Excess Lifetime Cancer Risk gives the probability of developing cancer over a lifetime at a given exposure level, It is presented as a value representing the number of extra cancers expected in a given number of people on exposure to a carcinogen at a given dose, and we can calculate (ELCR) by Eq (7) if considering 70 years as the average duration of life for human being[16].

$$ELCR = AEDE \times DL \times RF \tag{7}$$

where AEDE is the Annual Effective Dose Equivalent, DL is the average Duration of Life (estimated to be 70 years) and RF is the risk factor (Sv^{-1}), fatal cancer risk per Sievert. For low dose background radiations which are considered to produce stochastic effects, ICRP 60 uses values of 0.05 for the public exposure [16]. This value-free units because it represents the probability of cancer incidence through this we can deduce the equation above.

MATERIALS AND METHODS

Thirty samples of soil were collected from 6 sectors from Balad city in Salahaldeen, Iraq. Sample preparation was carried out by placing each soil sample in an oven for drying at a temperature of 100°C until a constant weight was reached to ensuring complete removal of any residual moisture. The dried samples were pulverized into a fine powder and passed through a standard 1 mm mesh size. The homogenized samples were filled into 1L Marinelli beakers. All samples were weighed (about 500gm) by using a high sensitive digital weighing balance with a percent of ±0.01%. The beakers were subsequently firmly sealed for at least four weeks to ensure a state of secular equilibrium between radium isotopes and their respective daughters [17]. Each sample was then counted by using Hyper Pure germanium Detector (HPGe).

Gamma spectrometer and relevant accessories were supplied by Canberra, USA used to measure the activity concentrations for each radionuclide in the soil. Each sample was identified for the radionuclide that is contaminating the soil, it has been used a very sophisticated, well advanced piece of equipment produced by ORTEC is hand held HPGe detector with an overall efficiency better than 42%. The resolution of this detector is 1.32MeV for ^{60}Co energy. The energy calibration of gamma-ray spectrometer is performed by ^{60}Co radioactive source**.**

The Study Area

Baladcity is about 85 kilometers north of the city of Baghdad,one of cities of the Salahadeen government. The geographical location corresponds to 34°0′59″N 44°08′43″E. Balad city was divided 17 sectors spaces equal ,the study include 6 sector in the city As it is shown in the map. The number of the city's population 55.334 thousand people. And through this information shows us clearly the importance of Balad city for the purpose of search. The map of Balad city was shown in Fig.1.

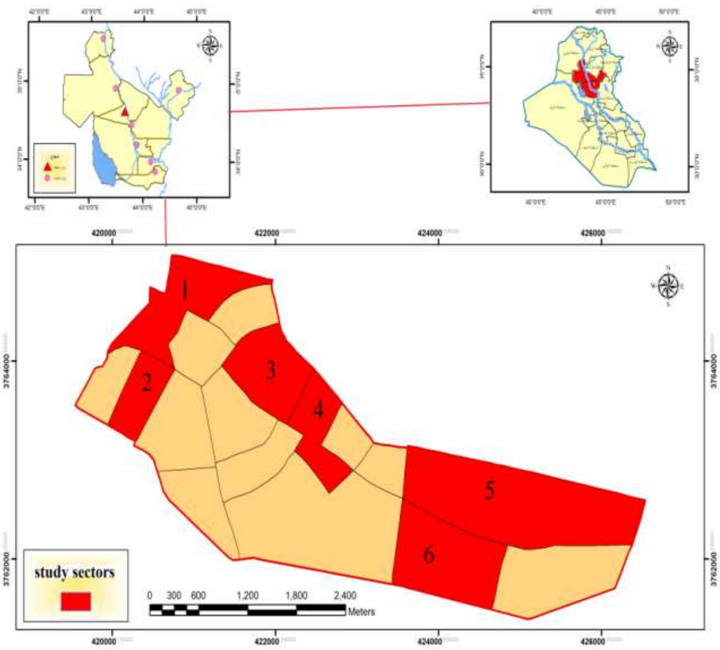

Fig.1: Map of Balad city sectors

RESULTS AND DISCUSSION

The specific activity of K^{40},Ac^{228} ,$Bi^{214}$and Cs^{137} soil samples are given in Table[1]. All values are given in Bq kg^{-1}. The activities range and mean values for K^{40},Ac^{228} ,$Bi^{214}$and $Cs^{137}$are ≤101.4812-1216.8329 (390.0661),≤ 0-8.7271 (1.90331),≤ 0-5.22 (0.485177),≤ 0 -1.4320 (0.250597) Bg.kg^{-1} respectively.

Table 1: Specific activity of radionuclide, the hazard indices and excess lifetime cancer risk for soil in Balad city

Sample ID	Ra eq (Bg/kg)	Absorbed dose rate (nGyh-1)	The annual effective dose (mSv/y) (Outdoor)(Indoor)		(Hex)	(Hin)	ELCR×10^{-3}
S1	24.308	13.036	0.0159	0.0639	0.0656	0.0656	0.0561
S2	14.121	6.949	0.0085	0.0340	0.0381	0.0381	0.0299
S3	33.488	17.995	0.0220	0.0882	0.0904	0.0907	0.0775
S4	25.044	13.416	0.0164	0.0658	0.0676	0.0693	0.0577
S5	25.141	12.536	0.0153	0.0615	0.0678	0.0690	0.0539
S6	16.625	8.866	0.0108	0.0434	0.0448	0.0448	0.0381
S7	36.604	18.405	0.0225	0.0902	0.0988	0.0988	0.0792
S8	41.909	22.324	0.0273	0.1095	0.1131	0.1204	0.0961
S9	36.522	18.952	0.0232	0.0929	0.0986	0.0993	0.0815
S10	96.335	51.526	0.06319	0.2527	0.2601	0.2601	0.2218
S11	31.633	16.864	0.0206	0.0827	0.0854	0.0854	0.0726
S12	38.746	20.554	0.0252	0.1008	0.1046	0.1046	0.0884
S13	19.090	10.133	0.0124	0.0497	0.0515	0.0515	0.0436
S14	52.124	27.880	0.0341	0.1367	0.1407	0.1458	0.1200
S15	16.875	8.9938	0.0110	0.0441	0.0455	0.0483	0.0387
S16	20.686	10.950	0.0134	0.0537	0.0558	0.0619	0.0471
S17	44.123	23.115	0.0283	0.1133	0.1191	0.1191	0.0995
S18	26.587	13.812	0.0169	0.0677	0.0717	0.0717	0.0594
S19	31.283	16.224	0.0198	0.0795	0.0844	0.0844	0.0698
S20	26.628	13.198	0.0161	0.0647	0.0719	0.0860	0.0568
S21	20.857	11.214	0.0137	0.0550	0.0563	0.0563	0.0482
S22	21.576	11.457	0.0140	0.0562	0.0582	0.0582	0.0493
S23	27.570	14.802	0.0181	0.0726	0.0744	0.0744	0.0637
S24	18.586	9.945	0.0121	0.0487	0.0501	0.0501	0.0428
S25	35.197	18.541	0.0227	0.0909	0.0950	0.0950	0.0798
S26	43.264	22.885	0.0280	0.1122	0.1168	0.1168	0.0985
S27	30.097	16.143	0.0197	0.0791	0.0812	0.0812	0.0694
S28	40.456	21.748	0.0266	0.1066	0.1092	0.1092	0.0936
S29	71.638	38.397	0.0470	0.1883	0.1934	0.1934	0.1653
S30	30.140	15.869	0.0194	0.0778	0.0813	0.0813	0.0683
A.V	33.241	17.558	0.0215	0.0861	0.0897	0.0910	0.0756
W.A	370.00	55.000	0.0700	0.4500	1.0000	1.0000	0.2900

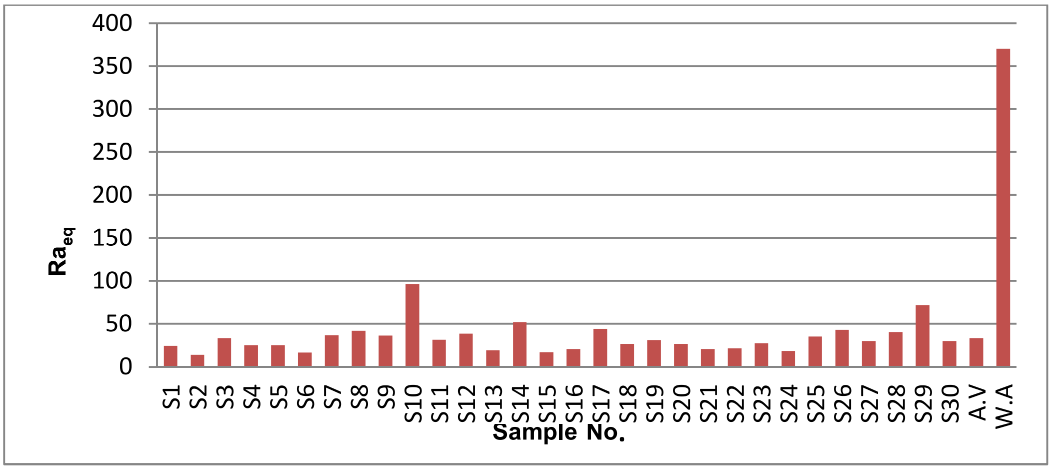

Fig.2: The relationship between Radium equivalent and sample number

The wide variations of the activity concentration values are due to their presence in the marine environment and their physical, chemical and geochemical properties [18,19]. The results show that the mean activity,Ac^{228},$Bi^{214}$and Cs^{137} are lower when compared with worldwide average values (35 Bq $kg^{-1}$for Bi^{214}, 30 Bq $kg^{-1}$for Ac^{228}) of this radionuclide while there increase in K^{40} in some sample(S_3,S_8,S_{10},S_{12},S_{14},S_{17},S_{25},S_{26},S_{28},S_{29}) in the soil[14]. As can be seen from Fig.2, the Raeq values for the soil samples varied from 107.788 in S_2sample to1219.472 Bq $kg^{-1}$with an average of 393.273 Bq kg^{-1}. The absorbed dose rate values range between 6.947and 51.526 with a mean value of 17.558 nGy $h^{-1}$was shown in Fig.3. These values were lower than the world average value; the published maximal admissible (permissible) dose rate is 55 nGy/h [20]**.** Also, the present values of outdoor and indoor annual effective dose equivalent were ranged from 0.0085mSv in S2 sample to 0.0632mSv in sample S10 with an average value of 0.0215mSv for outdoor; as shown in Fig.4 and the indoor annual effective doses ranged from 0.0340 mSv in S2 sample to 0.2527mSv in sample S10 with an average value 0.0861mSv for one year; as shown in Fig.5.All values of indoor and outdoor annual effective dose equivalent were lower than the world average values (0.07mSv/y for outdoor and 0.45mSv/y for indoor) [21].

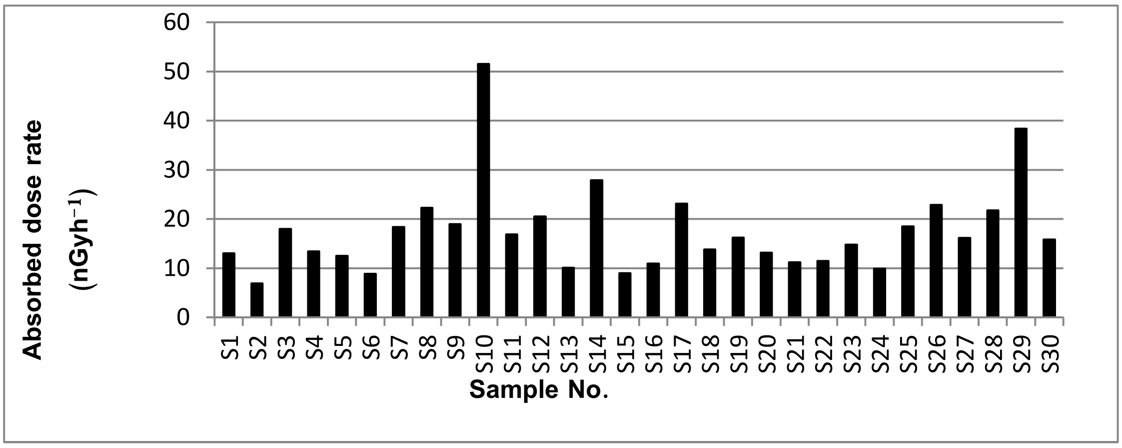

Fig.3: The relationship between the absorbed dose rate in air and sample number

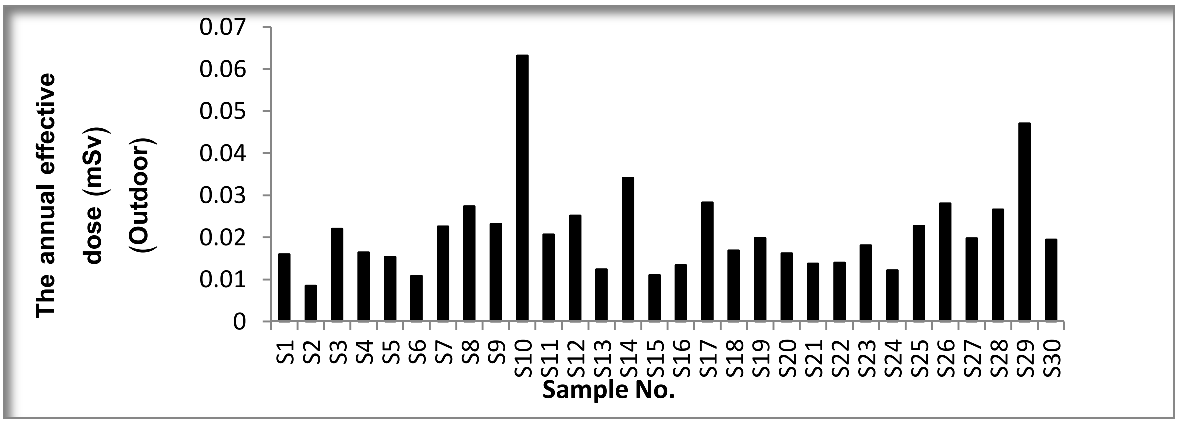

Fig.4: The relationship between the annual effective dose outdoor and sample number

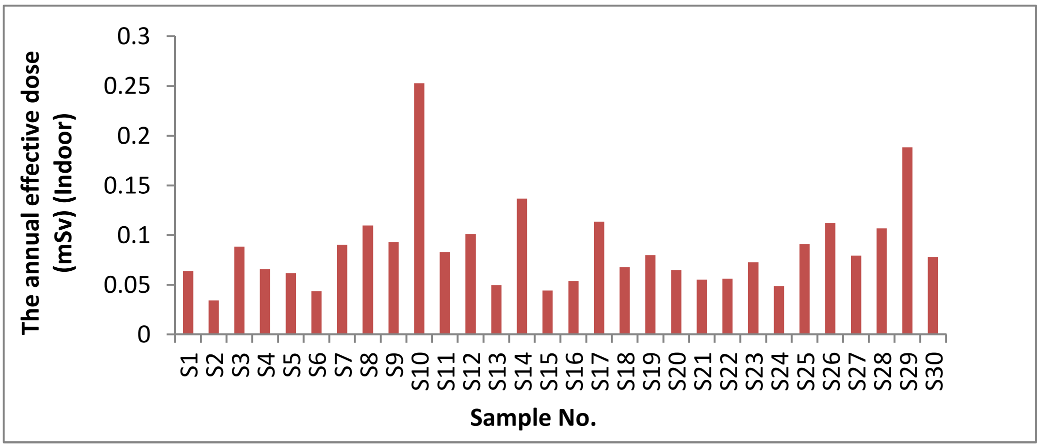

Fig.5: The relationship between the annual effective dose indoor and sample number

Figs.6 and 7 show the external hazard values are between 0.0.0381 in S_2 sample and 0.2601 in S_{10} with average 0.0897 and the internal hazard values between 0.0.0381 inS_2 sample and 0.2601 in S_{10}samplewith average 0.0910. All external and internal indices values are less than the world permissible value of unity [21].

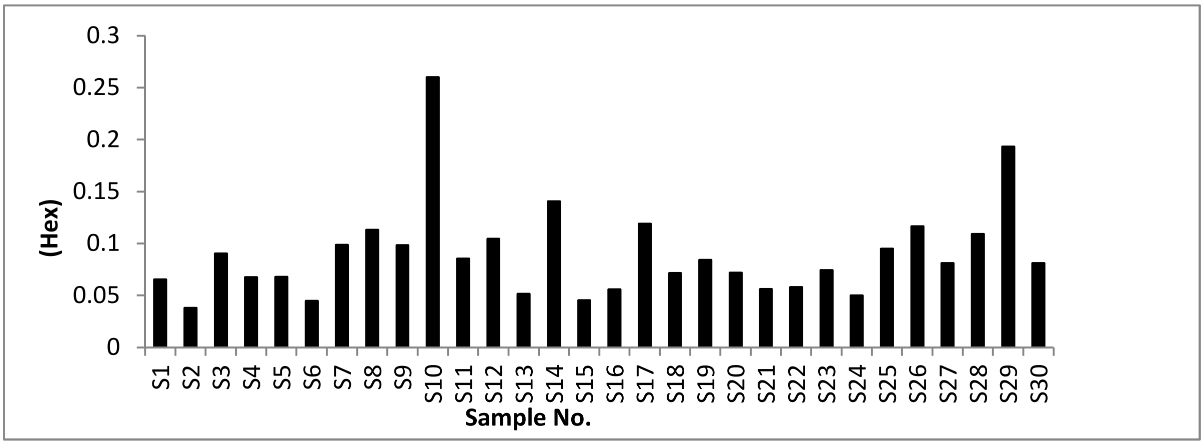

Fig.6: The relationship between the external hazard index and sample number

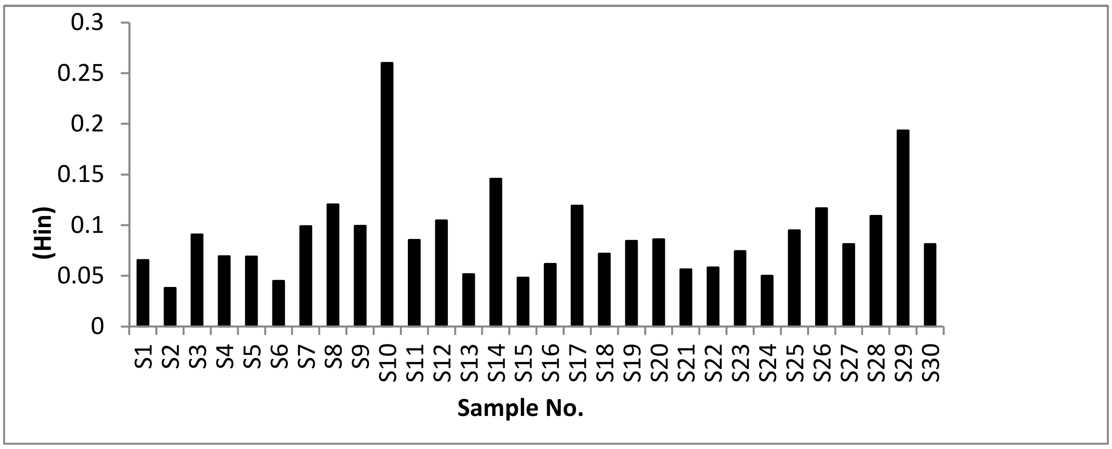

Fig.7: The relationship between the internal hazard index and sample number

Fig.8 shows the Excess Lifetime Cancer Risk values which ranged from 0.0299 in S2 sample to 0.2218 in S10sampleand the average value 0.0755.

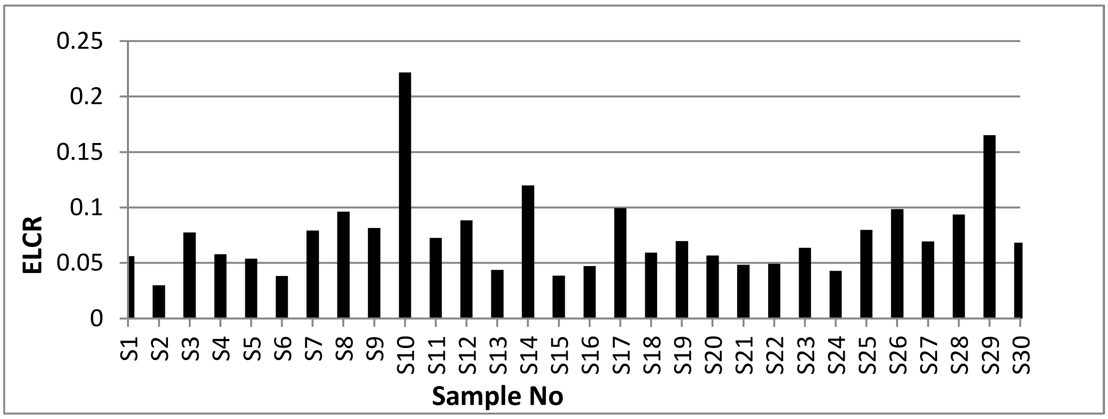

Fig.8: The Excess Lifetime Cancer Risk as a function of soil samples number

CONCLUSION

The present study was carried out to give a baseline reference data about the natural radioactivity levels from natural radionuclides in Balad soil. Soil measurements covering six main distinct locations were made. The absorbed dose rate in outdoor air was of mean value17.558 nGy/h, which is below the corresponding worldwide average value of 55 nGy/h. The annual effective dose equivalent and the hazard indices were lower than that of the acceptable values for safe. As a result, Balad soil has low natural radioactivity so it is safe for population living and can be used as a building raw materials or other human activities without any radiological risk.

REFERENCES

[1] United States Environmental Protection Agency, USEPA, **2012**.
[2]UNSCEAR, Sources and Effects of Ionizing Radiation, United Nations Scientific Committee on the Effect of Atomic Radiation Report Vol.1 to the General Assembly, with Scientific Annexes. United Nations Sales Publication, United Nations, New York,**2000**.
[3]WNA,WorldNuclearAssociation,**2009**.
[4] K.Tagami, S.Uchida, Y.Uchihori, N.Ishii, H.Kitamura, Y.Shirakawa, *TotalEnviron*.**2011**, 409, 4885–4888.
[5]G.Karahan, A.Bayulken, *Journal of Environmental Radioactivity*,**2000**, 47, 213–221.
[6]A.Matiullah, Sh.Ur-Rehman, A.Ur-Rehman, M.Faheem, *Radioactivity Protection Dosimerty*,**2004**,112 (3), 443–447.
[7]Tzortzis, M., Tsertos, H., *Journal of Environmental Radioactivity*,**2004**, 77, 325–338.
[8] Patra, A.K., Sudhakar, J., Ravi, P.M., James, J.P., Hegde, A.G., Joshi, M.L., *Journal of Radio analytical and Nuclear Chemistry*,**2006**, 270 (2), 307–312.
[9]Veiga, R., Sanches, N., Anjos, R., *Radiation Measurements* **2006**, 41, 189–196.
[10] P.Kessaratikoon, S.Awaekechi, *KMITL Science Journal*, 8(2) section A, July–December.**2008**.
[11] S.Dimovska, T.Stafilov,R.Sajn, *Radiation Protection Dosimetry*, **2011**,1–14.
[12]A.K. Mahur, R.G.Rajesh Kumar, D. Sonkawade, R.P. Sengupta, *Mater. Atoms*,**2008**, 266, 1591–1597.
[13]United Nations Scientific Committee on the Effects of AtomicRadiation (UNSCEAR), Sources, Effects and Risks of IonizingRadiation. Report to the General Assembly with Annex B, UnitedNations, New York, **2000**.
[14]D.C.Kocher, A.L.Sjoreen, *Healthy Phys*.**1985**, 48,193-205.
[15] J.Beretka, P.J.Mathew, *Health Phys*.**1985**,48, 87–95.
[16]H.M.Taskin,P. Ay. A.Karavus, S.Touzogh, Hindiroglu and G.Karaham, *Journal of Environmental Radioactivity*,**2009**, 100,49-53.
[17]R. A.Onoja, Total radioactivity count in taps and well water around Zaria area, Kaduna State, Nigeria. Ph.D. Thesis, ABU, Zaria. Nigeria.**2010**.
[18] S.A.Khatir, M.M.O.Ahamed, F.A.El-Khangi, Y.O. Nigumi, E.Holm, *Mar. Pollut. Bull*. **1998**, 36, 19–26.
[19] M.H.El-Mamoney, A.E.M.Khater, *J. Environ. Radioact*.**2004**, 73, 151–168.
[20] EPA: US Environmental Protection Agency. Technical Support Document, Citizen’s Guide to Radon.Washington DC; EPA 400-R-92-011.**1992**.
[21] Y.Orgun, N.Altinsoy, S.Y.Sahin, Y.Gungor, A.H.Gultekin, G.Karaham andZ.Karaak,*Applied Radiation and Isotopes*, **2007**, 65,739-747.