CALCULATION OF RADIOACTIVITY LEVELS FOR VARIOUS SOIL SAMPLES OF NEIGHBORHOOD AL RAHMAH (IRAQ)

Shatha F. Alhous[*a], Lubna A.Alasadi [**] , Shaymaa Awad Kadhim[***] , Hayder H. Hussain [****] ,Rusul Mohammed alkhafaji[*****]
University of Kufa/ Faculty of Education for girls/ Department of physics/ Iraq[*a]

Email :shathaf.alfatlawi@uokufa.edu.iq[*a]
Email :lubna.alasadi@uokufa.edu.iq
Email:shaymaa.alshebly@uokufa.edu.iq
Email :hayder.alshibana@uokufa.edu.iq
Email :rosolm.alkhafaji@uokufa.edu.iq

Abstract

The study of soil pollution and measuring the concentrations of radionuclides in the soil is of utmost importance, because many factors lead to an increase in these concentrations, and thus the nuclides move from the soil to plants and livestock and then to the human being, causing him serious health risks. Where taken 15 samples of soils from Al Rahmah district, Where the reagent of Thallium-impregnated Sodium Iodide NaI(TI) was used to measure the specific activity of the ^{226}Ra, ^{232}Th and ^{40}K nuclei, the specific activity values were varied from (0.526 -5.385) Bq.kg^{-1} with mean (2.193 Bq.kg^{-1}) for ^{226}Ra, (0.56 -5.29) Bq.kg^{-1} with average (2.95 Bq.kg^{-1}) for ^{232}Th and (209.239-990.387) Bq.kg^{-1} with mean (598.714 Bq.kg^{-1}) for ^{40}K, respectively. Specific activity values showed that there was only a significant increase in(^{40}K)concentrations, while that the difference between the rate of Thorium and Radium concentrations was little .External and internal hazard indices, outdoor and indoor absorbed doses and Radium equivalent activity and total annual effective dose which were below the internationally recommended limits. The excess life-time cancer risk (ELCR) was ($0.717*10^{-3}$) which compare with the worldwide value($1.45*10^{-3}$), this is the first study in this region and can be considered as a baseline for future studies in this region.

Keyword: *Soil, Gamma spectroscopy, specific activity, ELCR , Al Rahmah, Iraq.*

INTRODUCTION

U-238, Th-232 and K-40 These three radionuclides are naturally present in the earth's crust, the two main sources are (^{238}U series, ^{232}Th). The artificial source is (^{137}Cs). These radionuclides are released into the environment due to various human activities such as wars, the manufacture of weapons, scientific experiments, nuclear accidents, military operations, etc. ... from various activities. (Chernobyl disaster in 1986 and Fukushima earthquake in 2011) (Kapdan, Varinlioglu, & Karahan, 2011). These radionuclides (Uranium, Thorium, and decay products) have major impacts on human health due to their decay and thus the emission of ionizing radiation. Therefore, it is necessary to study this phenomenon and its effects on humans in particular and on the environment in general.(Barescut et al., 2011). To protect the environment, the natural radioactivity (radioactive background) in soil and rocks must be known and measured for the purpose of treating and controlling them within safety limits. (Iqbal, Tufail, & Mirza, 2000) . As for the level of radiation, it varies from one place to another on the surface of the earth, and the concentration of radionuclides in the soil depends on the concentrations of these nuclides in the substrate that make up the soil, as for plants, the soil is the main source of radionuclides concentrated in the parts of these plants. (Al-Hamarneh & Awadallah, 2009).

The radioactivity background of soil increases in agricultural areas due to the use of phosphorous fertilizers, as the concentrations of natural radionuclides in phosphorous fertilizers are equal to their percentage in the soil or may be more than ten times more. Thus, it can be said that the use of phosphorous fertilizers for the purpose of agriculture, as well as the process of storing them and the process of transporting them, will cause direct exposure, and therefore all of this represents an additional dose for the farmer, the consumer and the environment.(Snyder, Bruulsema, Jensen, & Fixen, 2009). Therefore, it is necessary to set limits for the concentrations of these nuclides (NORMs) that are included in the composition of these fertilizers. These isotopes (Uranium, Thorium, and Potassium) enter the human body through various nutrients, as plants absorb these nuclides through their roots and thus move to the leaves and fruits, both of which represent a major human food, and thus result in an internal dose in the human body.(Koranda & Robison, 1978) . There are many studies on soil contamination with radionuclides (Vig, Megharaj, Sethunathan, & Naidu, 2003). Accordingly, contaminated soil is a source of radionuclides for various agricultural crops as well as for natural plants, and therefore it is transmitted to animals and ultimately to humans by eating radioactively contaminated meat and vegetables, which will negatively affect human health and lead to disastrous consequences. (Prasad, 2003). The purpose of this research the natural radioactivity contents, Radium equivalent activity, external and internal radiation hazard indices, representative level index ($I\gamma$) ,effective dose rate (D_{eff}) and the risk cancer in the surface soils of Al Rahma neighborhood. The data provided in this study will be baseline.

ANALYTICAL TECHNIQUE

Study area

Najaf is one of the cities of central Iraq which is located to southwest of the capital ,Baghdad .It has an area of 864 km and is about 60 m above sea level. it's one of the important cities in Iraq due to the Najaf sea is the most important geographical phenomenon in the city .also, the presence of religious shrines , Imam Ali shrine is the most important one which located in the city center . Al Rahmah neighborhood, about(3 km) from Imam Ali shrine , was chosen for this study due to appearance of many cases of cancer in this region. Moreover , it’s a popular area with high population and its streets are not paved, so the residents are in direct exposure to soil.

SAMPLE COLLECTION AND MEASURING METHODS

In 2013 , Fifteen samples were collected within the boundaries of Al-Rahmah administrative district after the area was divided into fifteen parts, and each sample was taken from the center of that part. Where the Figure 1 represented the map of Iraq is where the Najaf Province is located and that samples location are indicated in Al-Rahma neighborhood where the radiation level was measured.

Fig 1. Map showing the locations of sampling for *Al Rahmah*, Najaf ,Iraq .

After removing the soil of a depth ranging between (5 to 10 cm) in order to remove the upper layer exposed to impurities and dirt, samples with a weight of one kilogram were taken from each site, and then they were transferred to the research laboratory in the College of Science, Physics Department in university of kufa , for the necessary tests. After that, the process of preparing samples for examination begins, the first step is to dry the sample (soil), using an oven at a temperature of 80 ° C, in order to get rid of the moisture permanently. After that, the dirt, grit, leaves, and unwanted parts are removed using a sieve with holes of 2 mm, then packed in the system's Marnelli container and closed tightly. Then samples were stored for a month in order to obtain a balance between Radium nuclies (^{226}Ra and ^{228}Ra). After that, examine the samples to measure the radioactivity of natural radioactive nuclei by using an Ortec-digiBASE gamma-ray spectrometer based on the $3'' \times 3''$ NaI detector with 6.8% energy resolution at 662 keV for ^{137}Cs. The ScintiVision^{TM}-32 software was installed in the computer for data analysis, and the energy and efficiency of the system were calibrated. The measurement time was (28800 second). Before examining the soil samples, an empty marinelli container was examined in order to measure the background radiation in the laboratory .The values of energiees 1460 keV for ^{40}K, 1764 keV for ^{214}Bi and 2614 keV for ^{208}Tl were adopeted to meaesure the radioactivity for the ^{40}K, ^{226}Ra and ^{232}Th nuculei respectiveley.

CALCULATIONS

the specific activity in (Bq.kg^{-1})units was calculated by using the equation (1) (Hussain & Hussain, 2011).

$$\mathcal{A}_n = \frac{(\mathcal{C}_n - \mathcal{C}_b)}{t \varepsilon_\gamma I_\gamma m_s} \quad ..(1)$$

Where $\mathcal{A}_n$ is The activity of each nucleus is measured in units Bq.kg^{-1}, $\mathcal{C}_n$ the count rate in cps for a saimple, $\mathcal{C}_b$ the counet rate in cps for baeckground, ε_γ and I_γ are detection efficiency and emission probability of γ-ray, t is the couenting time and m_s is the mass of the sample in kg . Factor was used to calculate the effect of the three radionuclides *^{40}K, ^{226}Ra and ^{232}Th*, because their concentrations are not equal in soil and rocks (Ra_{eq}) as proposed by the Organizeation of Econeomic Cooperaition and Developement (Ahmad, Jaafar, & Alsaffar, 2015). And so will we calculate , representative level index (Iγ) , effective dose rate (D_{eff}, D_{eff1}), internal hazard index (H_{in}), internal hazard index (H_{ex}) and absorbed dose rate (D_{in} , D_{out}) in soil samples. Likewise, we considered the Excess Life-time Cancer Risk (ELCR**)** account for them as important to human life.this risk due to radiation effects can be calculated from the following equation (Avwiri, Ononugbo, & Nwokeoji, 2014).

$$ELCR = AEDE * LS * RF \quad .. (2)$$

AEDE: The Annual Effective Dose Equivalent.

LS: is a mean life span for adult (66 years).

By offsetting these variables we will get the (ELCR) of ^{226}Ra, ^{232}Th and ^{40}K in the soil samples .The value of risk factor (RF) for stochastic effects in the population is 0.05 per Sievert as recommended by ICRP (James & Birchall, 1995) .

RESULT AND DESCUSSION

Table No. 1 includes radionuclide concentrations and ratio of these concentrations for the studied soil samples.

Table 1. The specific activity of ^{226}Ra, ^{232}Th and ^{40}K and their ratios in soil samples collected from Al Rahmah.

sample code	Specific Activity (Bq.kg^{-1})			Ratios		
	^{226}Ra	^{232}Th	^{40}K	Ra/K	Th/K	Th/Ra
S_1	2.629±0.55	2.56± 0.23	856.61± 2.11	0.0031	0.0030	0.98
S_2	1.606±0.64	2.01± 0.25	990.38±2.08	0.0016	0.0020	1.25
S_3	2.018±0.81	1.01±0.19	982.05± 2.09	0.0021	0.0010	0.50
S_4	1.165±0.55	1.54±0.22	975.89± 2.16	0.0012	0.0016	1.32
S_5	3.708±0.72	1.28±0.19	916.92± 2.03	0.0040	0.0014	0.35
S_6	0.526±0.48	0.56±0.15	866.77±2.16	0.0006	0.0007	1.07
S_7	0.796±0.47	0.98±0.21	879.10± 2.04	0.0009	0.0011	1.24
S_8	1.733±0.45	2.00±0.19	842.28± 1.99	0.0021	0.0024	1.15
S_9	5.385±1.07	5.29±0.40	223.44± 3.39	0.0241	0.0237	0.98
S_{10}	1.080±0.24	4.22±0.15	258.48± 2.29	0.0042	0.0163	3.91
S_{11}	1.051±0.21	4.41±0.16	262.39± 2.23	0.0040	0.0168	4.19
S_{12}	1.989±0.20	3.69±0.15	254.23± 2.18	0.0078	0.0145	1.85
S_{13}	4.731±0.99	5.28±0.39	240.09± 3.43	0.0197	0.0220	1.12
S_{14}	1.051±0.26	4.21±0.16	220.58± 2.28	0.0048	0.0191	4.00
S_{15}	1.904±0.51	5.28±0.40	209.23± 2.09	0.0091	0.0252	2.77
max	5.385	5.29	990.3877	0.0241	0.0252	4.19
min	0.526	0.56	209.2392	0.0006	0.0007	0.35
mean	2.193	2.95	598.7149	0.0067	0.0104	1.84
Worldewide(Charles , 2010; Rangaswamy, Srinivasa Srilatha)	35	30	420	0.087	0.075	0.86

From Table 1 we can see that the values of ^{226}Ra and ^{232}Th specific activity for the soil samples in this study with maximum values in sample S_9. While the minimum value of them were recorded in sample S_6 , in this study,and these values were significantly lower than the worldwide average recommended by UNSCAER [12].The measurements of the specific activity of the ^{40}K with maximum value in sample S_2 and a minimum value in sample S_{15} ,only(from S_1 to S_8) samples with average out of fifteen samples have specific activity values of ^{40}K higher than the worldwide average value (420 $Bq.kg^{-1}$) recommended by the UNSCAER, We observe a high concentration of potassium in many soil samples may be due to the fact that a war in this region in 2004 between Iraq and US forces or due to the soil Geology. The ratios were used for the purpose of comparison and to give a clearer picture of the concentrations of these nuclides, from Table 1 we can show that the concentrations of Thorium are greater slightly than the concentrations of Radium , but both less than the concentrations of Potassium .This is due to the marked increase in potassium concentrations ,the ratio between concentrations of Th/K and Ra/K are close together while the ratio of Th/Ra is higher than the global limits.the maximum values of Rdium equivalent activity, representative level index , external hazard index, outdoor absorbed dose, internal hazard index , indoor absorbed dose, annual effective dose equvilent and cancer risk in sample S_2 , the reason could be the high Potassium concentration activity in this sample ,while the minimum values in sample S_{14} as shown from Table 2 , all values of the indicators are less than the permissible limits except for the annual effective doses equvilent, they are greater than the limits of worldwide [12]. It is important to focus on the risk of cancer by using the equation (2) which gives a risk factor of ($0.717*10^{-3}$), the estimated values are significantly less than the ICRP cancer risk of (1.45×10^{-3}) This indicates that the soil in this region is safe and has no negative effects on human health (Mohammed & Ahmed, 2017)

Table 2. Calculated values of hazard indices for soil samples collected from Al Rahmah.

ID	Ra_{eq} ($Bq.Kg^{-1}$)	I_γ ($Bq.Kg^{-1}$)	H_{ex}	D_{out} ($nGy.h^{-1}$)	H_{in}	D_{in}	D_{eff} ($mSv.y^{-1}$)	D_{eff1} ($mSv.y^{-1}$)	Cancer risk
S_1	72.256	0.614	0.195	39.655	0.202	51.55	0.048	0.252	0.995
S_2	80.742	0.691	0.218	44.604	0.222	57.98	0.054	0.284	1.119
S_3	79.082	0.678	0.214	43.760	0.219	56.88	0.053	0.279	1.098
S_4	78.515	0.674	0.212	43.482	0.215	56.52	0.053	0.277	1.091
S_5	76.145	0.649	0.206	41.860	0.216	54.41	0.051	0.267	1.050
S_6	68.075	0.587	0.184	37.870	0.185	49.23	0.046	0.241	0.950
S_7	69.892	0.601	0.189	38.792	0.191	50.43	0.047	0.247	0.973
S_8	69.450	0.593	0.188	38.283	0.192	49.76	0.046	0.244	0.960
S_9	30.153	0.238	0.081	15.408	0.096	20.03	0.018	0.098	0.386
S_{10}	27.018	0.222	0.073	14.370	0.076	18.68	0.017	0.091	0.360

S_{11}	27.558	0.226	0.074	14.649	0.077	19.04	0.018	0.093	0.367
S_{12}	26.841	0.22	0.072	14.224	0.078	18.49	0.017	0.090	0.356
S_{13}	30.764	0.244	0.083	15.838	0.096	20.58	0.019	0.101	0.397
S_{14}	24.055	0.196	0.065	12.720	0.068	16.53	0.015	0.081	0.319
S_{15}	25.561	0.205	0.069	13.304	0.074	17.29	0.016	0.084	0.333
max	80.742	0.691	0.218	44.604	0.222	57.98	0.054	0.284	1.119
min	24.055	0.196	0.065	12.720	0.068	16.53	0.015	0.081	0.319
mean	52.406	0.442	0.142	28.597	0.147	37.17	0.035	0.182	0.717
worldewide (Charles, 2001, 2010)	370	<1	<1	59	<1	84	0.07	0.41	1.45

CONCLUSIONS

Soils in Al rahmah neighborhood has a significant increase in potassium activity concentrations may be due to geology of the soil or have been in the sea of Najaf. Where should be noted that the studyarea was previously agricultural land,which led to a high concentration of Potassium. While Radium and Thorium, their concentrations are low in this region compared with other countries in the world, .Finally the ELCR is lower than average world. UNSCEAR2000B, all values of hazard indices are less than the permissible limits.

ACKNOWLEGMENT

Sincere thanks to Dr. Murtadha Sh. Asoowd in department of Physics, college of education, university of Al- Qadisiyah, Iraq for clarifying several points in this research.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

REFERENCES

Ahmad, N., Jaafar, M., & Alsaffar, M. (2015). Natural radioactivity in virgin and agricultural soil and its environmental implications in Sungai Petani, Kedah, Malaysia. *Pollution, 1*(3), 305-313.

Al-Hamarneh, I. F., & Awadallah, M. I. (2009). Soil radioactivity levels and radiation hazard assessment in the highlands of northern Jordan. *Radiation Measurements, 44*(1), 102-110.

Avwiri, G., Ononugbo, C., & Nwokeoji, I. (2014). Radiation Hazard Indices and Excess Lifetime cancer risk in soil, sediment and water around mini-okoro/oginigba creek, Port Harcourt, Rivers State, Nigeria. *Comprehensive Journal of Environment and Earth Sciences, 3*(1), 38-50.

Barescut, J., Lariviere, D., Stocki, T., Pandit, G., Sahu, S., & Puranik, V. (2011). Natural radionuclides from coal fired thermal power plants–estimation of atmospheric release and inhalation risk. *Radioprotection, 46*(6), S173-S179.

Charles, M. (2001). UNSCEAR Report 2000: sources and effects of ionizing radiation. *Journal of Radiological Protection, 21*(1), 83.

Charles, M. (2010). Effects of Ionizing Radiation: United Nations Scientific Committee on the Effects of Atomic Radiation: UNSCEAR 2006 Report, Volume 1—Report to the General Assembly, with Scientific Annexes A and B: Oxford University Press.

Hussain, R. O., & Hussain, H. H. (2011). Investigation the natural radioactivity in local and imported chemical fertilizers. *Brazilian archives of biology and technology, 54*(4), 777-782.

Iqbal, M., Tufail, M., & Mirza, S. M. (2000). Measurement of natural radioactivity in marble found in Pakistan using a NaI (Tl) gamma-ray spectrometer. *Journal of environmental radioactivity, 51*(2), 255-265.

James, A., & Birchall, A. (1995). New ICRP lung dosimetry and its risk implications for alpha emitters. *Radiation protection dosimetry, 60*(4), 321-326.

Kapdan, E., Varinlioglu, A., & Karahan, G. (2011). Radioactivity levels and health risks due to radionuclides in the soil of Yalova, Northwestern Turkey. *International Journal of Environmental Research, 5*(4), 837-846.

Koranda, J. J., & Robison, W. L. (1978). Accumulation of radionuclides by plants as a monitor system. *Environmental health perspectives, 27*, 165-179.

Mohammed, R., & Ahmed, R. (2017). Estimation of excess lifetime cancer risk and radiation hazard indices in southern Iraq. *Environmental Earth Sciences, 76*(7), 303.

Prasad, M. (2003). Phytoremediation of metal-polluted ecosystems: hype for commercialization. *Russian Journal of Plant Physiology, 50*(5), 686-701.

Rangaswamy, D., Srinivasa, E., Srilatha, M., & Sannappa, J. (2015). Measurement of terrestrial gamma radiation dose and evaluation of annual effective dose in Shimoga District of Karnataka State, India. *Radiation Protection and Environment, 38*(4), 154.

Snyder, C., Bruulsema, T., Jensen, T., & Fixen, P. (2009). Review of greenhouse gas emissions from crop production systems and fertilizer management effects. *Agriculture, Ecosystems & Environment, 133*(3-4), 247-266.

Vig, K., Megharaj, M., Sethunathan, N., & Naidu, R. (2003). Bioavailability and toxicity of cadmium to microorganisms and their activities in soil: a review. *Advances in Environmental Research, 8*(1), 121-135.