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Measure the rate of Radiation Activity in Soil sample from the depth of Sindbad land in Basrah Governorate

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Abstract:

Uranium, radionuclide's, thorium and potassium are relatively abundant in soils. Because of their radiation, these radionuclide's pose exposure risks that can lead to health problems such as cancer for exposed people. There is therefore growing concern about the health risks associated with exposure to the natural sources of radiation in our environment. The specific activity of ²³⁸U, ²³²Th, ⁴⁰K, ²²⁶Ra in forty soil samples collected from different locations of Al-sindbad land in the province of Basra – Iraq using Sodium Iodide NaI(TL) detector. The specific activities for the whole study areas were compared the Local, world average and permissible recommended limits. The results showed that the specific activity of ²²⁶Ra, ²³²Th, ²³⁸U, and ⁴⁰K, in the samples range from (17.14-39.07) Bq/kg, (1.8-22.88) Bq/kg, (0.68-2.24) Bq/kg and (278.11-402.29) respectively, Also evaluation of radiological hazard effects for Gamma ray (the radium equivalent rate (Raeq) which calculated from concentration of ²³²Th, ²³⁸U and ⁴⁰K ranges between (30.72-65.48) Bq/kg with mean value of (43.362) Bq/kg, the absorbed dose Rate (D_γ) for the soil samples in the study area range from (26.54-43.92) nGy/h with an average value of (33.216) nGy/h, the annual effective dose rate (AEDE_{oo}) range (0.13-0.22) mSv/y with an average value of (0.163) mSv/y, The annual effective dose rate (AEDE_{in}) range (0.03-0.05) mSv/y with an average value of (0.04) mSv/y, The internal hazard index (Hin) range (0.2-0.35) with an average value of (0.255) and the external hazard index (Hex) range (0.15-0.25) with an average value of (0.186). The results of the present study have shown that the rates of Specific activity of ²²⁶Ra, ²³⁸U, ²³²Th and ⁴⁰K, and radiological hazard effects Rate for Gamma- ray in environmental samples were all lower than the value of the global limit (33, 35, 30, 400) Bq/kg respectively according to UNSCEAR. We conclude from this study that the environment of Al-Sindbad land in the province of Basra – Iraq is within a normal background radiation.

Keywords: Basra, Al-sindbad land, NaI(TL) detector

1-Introduction

The soil has always been important to human health. It provides a resource that can be used for food production. There for it needs a special monitoring program since it has a direct threat to health of human and environmental. It is the main source of food through its direct contact with the agricultural soil. Through the ingestion, inhalation and skin absorption the radionuclide and biological component of the soil therefore it can be threats the human health. Cancers caused by the inhalation of fibrous or radon gas derived from the radioactive decay of U in soil minerals [1]. The Know levels of concentration of natural radionuclide's in the soil and their distribution in the environment is of great interest in many field of sciences [2]. The programs of the scientific monitoring of environmental radioactivity in Iraq began in 1968 in the Atomic



Energy Organization and continued until March 2003. These were programs monitored the radiation activity of the Tuwaitha site in addition to monitoring various sites in the country. Where radioactive Monitoring systems were installed in different locations of the country which helped to detect radioactivity in the north of the country after the Chernobyl accident in 1986 and in the south of the country after the second Gulf War in 1991. The monitoring of the level of environmental radiation activity is of great importance to ensuring the safety of the community. Therefore, it is necessary to know the extent of the increase in this level because of its negative physical and genetic effects. This undesirable increase is known as radioactive pollution, which is a part of environmental pollution[3][4]. The main concept of soil pollution depends on information on moving in and accumulation away from the site of contamination. The accumulation and movement of radioactive materials depend on the interaction of materials and compounds with the soil. This interaction reflects the soil's ability to retain and moved radioactive material. The physical, chemical and biological properties of the soil determine their ability to retain radioactive materials. On the other hand, the rate of rainfall, irrigation water quantity, type of cultivated plants and soil management processes largely determine the type and amount of movement Radioactive pollutants into groundwater or to plants or other media such as air and water[5]. The different crust layers contain tiny amounts of uranium and thorium. The components of these chains are a major source of some radioactive gaseous products. In the uranium chain where the Radon gas is released from the radium element and the thoron gas is released from the thorium chain where release of these gases influences the organisms in the environment[5]. The importance of soil in this regard is that it is the final destination of radioactive materials and its long-term role is a reservoir of radioactive materials and at the same time as a source of these substances in air, water, plant and human pollution. Human beings and all living organisms are constantly exposed to radiation from two main sources: natural sources and man-made sources for multiple purposes. Man's exposure to natural sources is the fundamental proportion of exposure such as Cosmic Rays and natural background radiation, in particular natural uranium and radiation from elements naturally radioactive materials around us almost all have a small amount of radioactive material[6]. According to united Nation scientific committee on the effect of atomic radiation [UNSCEAR](1993), the world mean dose from natural adiation sources of normal areas is estimated to be 2.4mSvy^{-1} , while for all man-made sources, including medical exposure, is about 0.8mSvy^{-1} [7]. Thus 70% of the radiation dose received by human population is from natural radiation sources[8]. The main objective of this study is to evaluate the level of natural radiation in the soil collected from forty stations of Al-Sindbad land in the province of Basra and provides a base line data which can be used to evaluate possible future changes.

2- Materials and Methods:

2-1 The Study Area:

The area under study (Al-Sindbad land) is located innortheast of Basra Governorate in the south of Iraq ,(figure 1)[9]. It is located in the center of the Shatt al-Arab. The area falls between latitudes $30^{\circ} 30' \text{N}$ to $30^{\circ} 40' \text{N}$ and between longitudes $47^{\circ} 42' \text{E}$ to $47^{\circ} 50' \text{E}$ as shown in figure (2) [9]. It covers an area of approximately 180.000 Km^2 . The importance of this study is due to the fact that the study area is one of the agricultural and residential areas in Basrah Governorate. The above causes make it is necessary for baseline study such as this to determine the basic radioactivity levels which will serve as reference data for future studies.

2-2 Sample Collection and Preparation:

In the present work, a total of 40 surface samples at 0-5 cm depth level was collected from Sindbad land. The soil samples were collected in December 2018 and the point of collection of each sample were given a unique code as shown in figure(3)[10]. After transporting the samples to the laboratory, all soils were dried at 80°C for two hours, pulverized, homogenized, and sieved through 75µm. The sieved soil samples were weighed and stored in 1.4 liter Mirilany beakers. These plastic beakers are well-sealed for one month to allow secular equilibrium of ²²⁶Ra with its decay products in the uranium series transferred for radio nuclide analysis[11]. The collected soil samples were analyzed using a passively shielded Sodium Iodide (NaI) detector detector 3x3 inch with a 1024 channel computer analyzer USX supplied by Spectrum Technique Company, The detector is employed with lead shielding, 4 cm thickness, which reduced the background. The detector was calibrated using standard sources of ⁵⁷Co (peak 122 keV), ¹³⁷Cs (peak 662 keV) and ⁶⁰Co (peaks 1173, 1333 keV). The detector, based on high-resolution gamma and an energy resolution of (8 keV) for the 622 Kev gamma transition of Cs-137 the efficiency calibration was achieved using eight standard sources including the calibration sources. The system was running freely, for 12 h live time, to evaluate the background spectrum. The Marinelli beaker container sample was placed over the detector for counting. Activity concentration A_i of any gamma-rays line taken to represent this parameter for the environmental radionuclide's has been calculated using the relation (1)[12]. One of the sample spectrum shown in figure(4).

$$A_i = \frac{\text{Net count}}{\epsilon \times I_\gamma \times M \times t} \quad \dots (1)$$

where ϵ is absolute gamma peak efficiency of the detector at this particular gamma-ray energy, I_γ denotes the decay intensity for the specific energy peak (including the decay branching ratio information), M is the mass of the sample in kg and t is the counting time of the measurement in second. To evaluate activity concentrations of natural radionuclide's, one has to recognized the belong city of each peak according to gamma decay of each isotope [13]. For ²²⁶Ra we are looking for the gamma ray lines 295 keV (19.2%), 352 keV (37.1%), 609 keV (46.1%), 1120 keV (15%) and 1760 keV (15.4%). The peak of 186 keV assumed to be from ²³⁵U since it has slight effect on the total concentration after subtracting the background, 42.8% for Ra and the rest for ²³⁵U. The determination of existence of ²³²Th was achieved by 338 keV (12%), 911 keV (29%), 964 keV (5.05%) and 969 keV (17%). The case of ²³⁸U is recognized by 1001 keV (83%), 766 keV (29%) and 2204 keV (5%). For ⁴⁰K, where this directly was determined using 1460 keV (10%) peak.

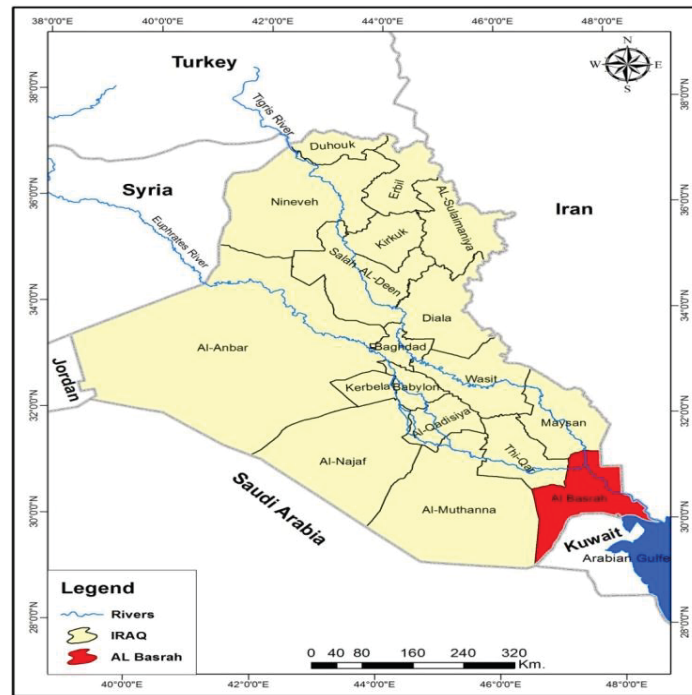


Figure (1):Sketched Geological Map of Iraq Showing the Study Area. [9]

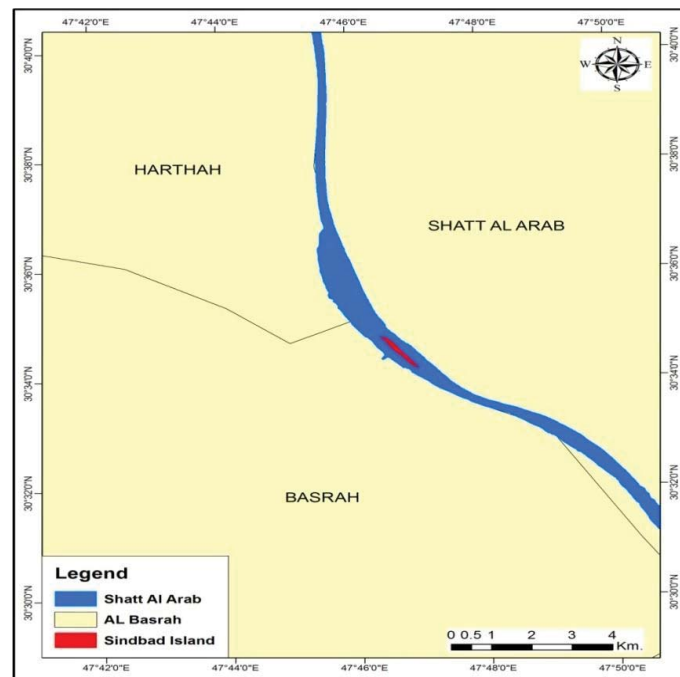


Figure (2):Geological Map of the Study Area.[9]

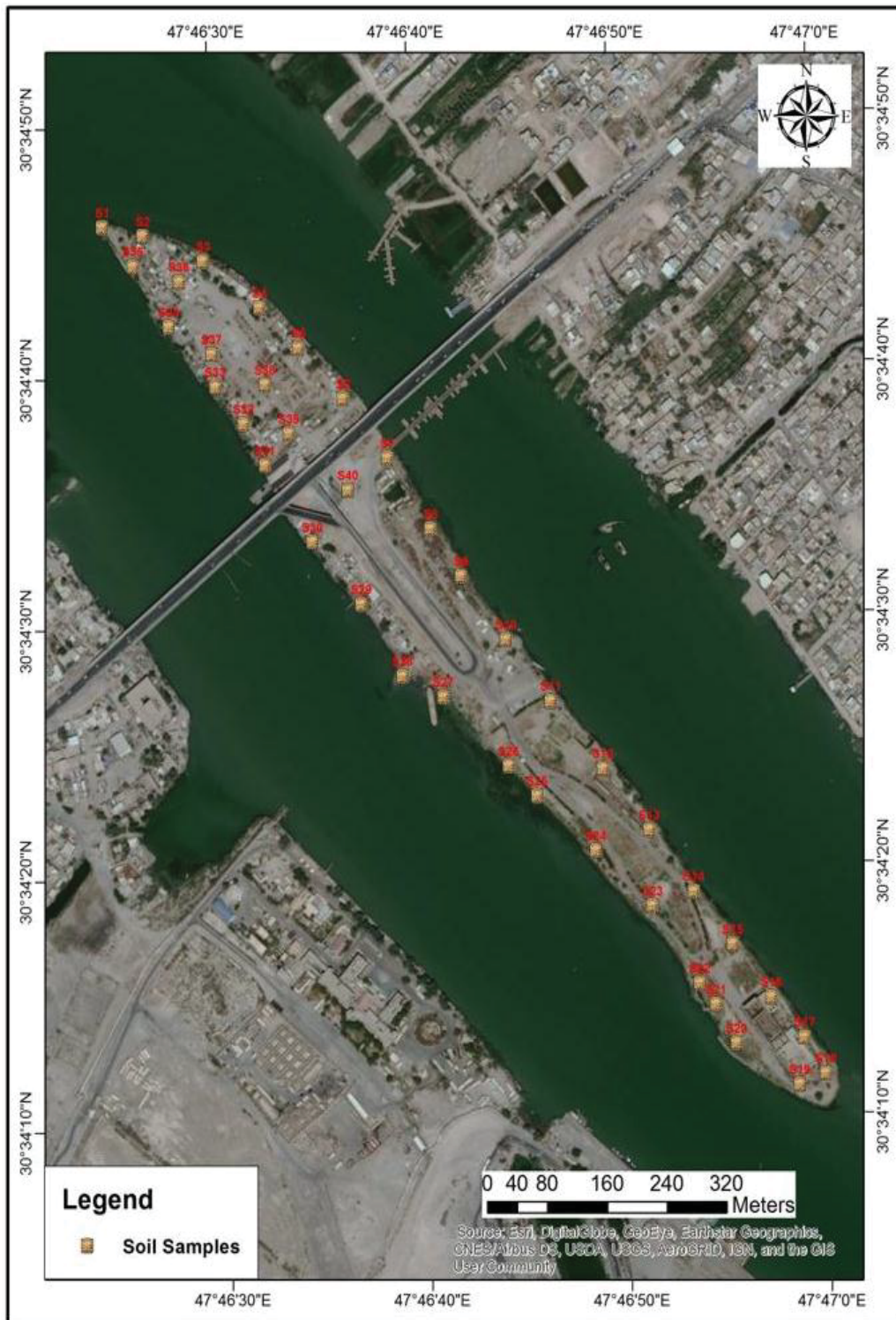


Figure (3):Geological Map of the Study Area Showing locations of soil sample[10]

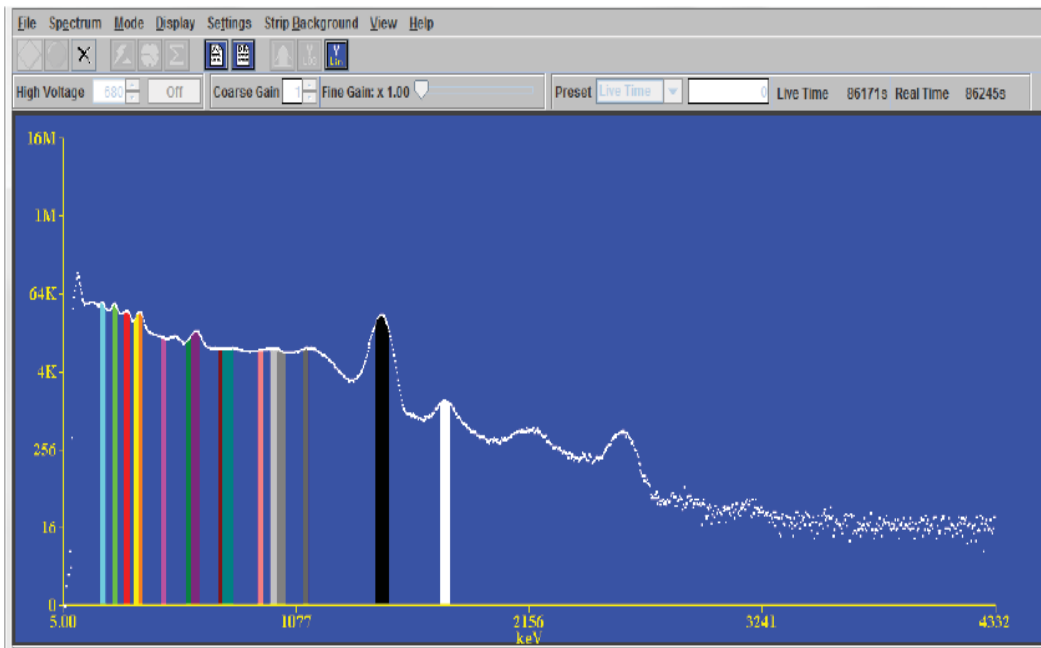


Figure (4): The NaI(Tl) spectrum of sample number3, where most of the peaks are clearly visible. The color represents the area under the peak of interest

2-3 GAMMA RADIATION PARAMETERS

1-Radium Equivalent Activity (R_{eq}): To represent the activity concentrations of ^{226}Ra , ^{238}U , ^{232}Th and ^{40}K by a single quantity, which takes into account the radiation hazards associated with them, a common radiological index has been introduced. The index is called radium equivalent activity (R_{eq}) which is used to ensure the uniformity in the distribution of natural radionuclides ^{238}U , ^{232}Th and ^{40}K and is given by the expression [14]:

$$R_{eq} \text{ (Bq/kg)} = A_{Ra} + 1.43A_{Th} + 0.077A_K \tag{2}$$

Where A_{Ra} , A_{Th} and A_K are the specific activity concentrations of ^{226}Ra , ^{232}Th and ^{40}K in (Bq/kg) respectively

2- Absorbed Gamma Dose Rate (D_γ): Outdoor air, gamma absorbed dose rate (D) in (nGy/h) due to terrestrial gamma rays at (1 m) above the ground surface which can be computed from specific activities A_{Ra} , A_{Th} and A_K of ^{226}Ra , ^{232}Th and ^{40}K in (Bq/kg) respectively using the following relation [14]:

$$D \left(\frac{nG}{y} \right) = 0.462 A_{Ra} + 0.604 A_{Th} + 0.0417 A_K \text{ (nGy.h}^{-1}\text{)} \tag{3}$$

3-Annual Effective Dose Rate (AEDE): The estimated annual effective dose equivalent received by a member was calculated by using a conversion factor of (0.7

Sv/Gy), which was used to convert the absorbed rate to human effective dose equivalent with an outdoor occupancy of 20 % and 80 % for indoors[15]:

$$AEDE_{out}(mSv.y^{-1})=D(nGy.h^{-1})\times 8760h\times 0.7Sv.Gy^{-1}\times 0.2\times 10^{-6} \quad (4)$$

$$AEDE_{in}(mSv.y^{-1})=D(nGy.h^{-1})\times 8760h\times 0.7Sv.Gy^{-1}\times 0.8\times 10^{-6} \quad (5)$$

4-External (Hex) and Internal (Hin) Hazard Indices: The external hazard index is obtained from (Raeq) expression through the supposition that it's allowed maximum value (equal to unity) correspond to the upper limit of Raeq (370 Bq/kg). Internal exposure to ²²²Rn and its radioactive progeny is controlled by the internal hazard index (Hin) as given below[14]:

$$H_{in} = \frac{A_{Ra}}{185} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \quad (6)$$

The external hazard index (Hex) can then be defined as given below[10]:

$$H_{ex} = \frac{A_{Ra}}{370} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \quad (7)$$

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

3. RESULTS AND DISCUSSION

The measured values of natural radioactivity concentration for ²²⁶Ra, ²³²Th, ²³⁸U and ⁴⁰K for different location of Sindbad land in Basra governorate, it can be noticed that the highest value of specific activity of (²³⁸U) was found instation(S₁), which was equal (2.24Bq/kg). While the lowest value of specific activity of U²³⁸ was found in (S₂₈) region, which was equal to (0.68 Bq/kg), with an average value of (1.35Bq/kg)as shown inTable (1) figure (5).

The highest value of specific activity of (²³²Th) was found in station (S₁), which was equal to (22.88Bq/kg), while the lowest value of specific activity of (²³²Th) was found in (S₁₃) region, which was equal to (1.8Bq/kg), with an average value of (10.16Bq/kg). The highest value of specific activity of (⁴⁰K) was found in (S₈) region, which was equal to (402.29Bq/kg) which is higher than the commanded level(400) according to UNSCEAR. It may be due to the geological nature of the area and the uncontrolled use of chemical fertilizers, while the lowest specific activity concentration of (⁴⁰K) was found in (S₅) regions which was equal to (278.11Bq/kg), with an average value of (360.55Bq/kg).The highest value of specific activity of (²²⁶Ra) was found in station(S₇) which was equal to (39.07Bq/kg) and the lowest value was(17.14Bq/kg) which was found in station(S₃₄), with an average value of(26.11Bq/kg)

Table 1: The activity concentration of Radium, Thorium, Uranium and Potassium for soil samples from Sindbad island in Basrah governorate

Number of samples	²²⁶ Ra Bq/kg	²³² Th Bq/kg	²³⁸ U Bq/kg	⁴⁰ K Bq/kg
S ₁	22.41	22.88	2.24	338.4
S ₂	24.61	2.15	1.11	395.05
S ₃	38.09	11.02	1.39	380.74
S ₄	19.76	12.21	1.15	394.57
S ₅	21.77	11.23	1.41	278.11
S ₆	28.85	11.08	1.37	383.79
S ₇	39.07	12.51	1.05	395.05
S ₈	35.34	14.8	1.76	402.29
S ₉	33.71	9.17	1.44	387.01
S ₁₀	34.67	15.86	1.66	383.79
S ₁₁	38.85	16.56	1.37	382.83
S ₁₂	38.43	13.92	1.13	392.48
S ₁₃	38.99	1.8	1.2	372.21
S ₁₄	25.78	7.67	1.55	368.19
S ₁₅	24.75	6.94	1.19	376.39
S ₁₆	23.44	13.27	1.48	315.59
S ₁₇	25.69	10.74	1.45	357.09
S ₁₈	26.12	15.16	1.61	355.8
S ₁₉	23.64	9.07	1.84	387.01
S ₂₀	21.05	11.14	1.58	338.43
S ₂₁	22.79	12.1	1.65	355.64
S ₂₂	22.09	8.73	1.14	356.13
S ₂₃	23.96	8.7	1.5	370.28
S ₂₄	21.72	8.77	1.29	370.44
S ₂₅	27.26	10.34	1.05	339.56
S ₂₆	21.52	5.1	1.27	323.96
S ₂₇	25.06	5.01	1.39	322.02
S ₂₈	21.94	11.51	0.68	357.89
S ₂₉	25.13	8.93	1.23	307.23
S ₃₀	19.88	8.53	1.52	315.5
S ₃₁	23.42	5.6	1.47	381.06
S ₃₂	24.79	7.49	1.52	379.61
S ₃₃	22.13	8.12	1.07	344.22
S ₃₄	17.14	13.22	1.27	360.47
S ₃₅	23.88	12.91	1.42	371.57
S ₃₆	23.47	6.11	1.03	372.53
S ₃₇	21.99	6.26	1.26	341.01
S ₃₈	23.15	9.29	1.16	376.55
S ₃₉	24.31	12.42	1.04	347.44
S ₄₀	23.93	8.13	1.29	344.22
Average	26.11	10.16	1.35	360.55
Max	39.07	22.88	2.24	402.29
Min	17.14	1.8	0.68	278.11

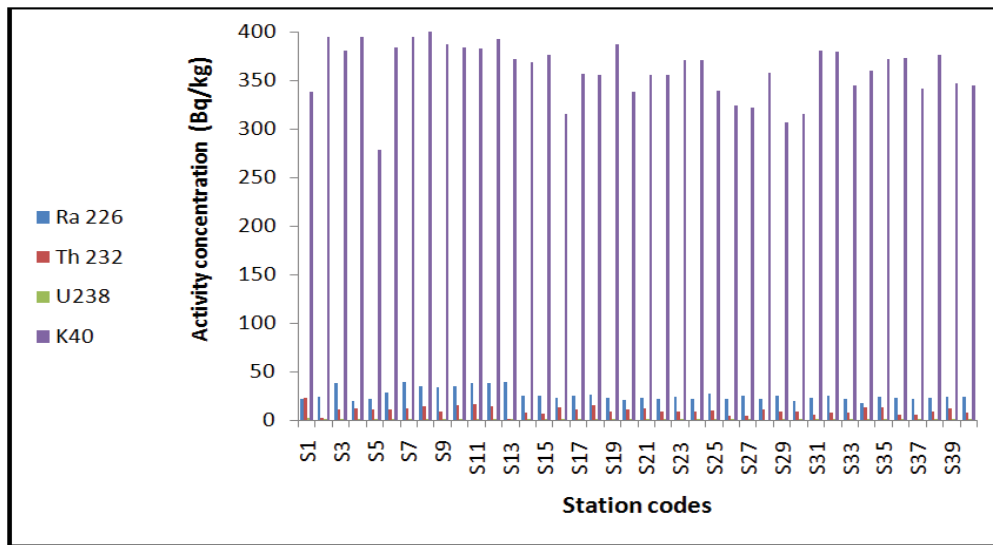


Figure (5): Comparison between values of ^{238}U , ^{226}Ra , ^{232}Th and ^{40}K activity concentration in Bq kg^{-1} for soil samples from Sindbad island in Basrah governorate

From Table (2) it can be noticed that the highest value of radium equivalent activity (R_{eq}) was found in (S_{11}) station, which was equal to (65.48Bq/kg), while the lowest value of radium equivalent activity was found in (S_2) station which was equal to (30.72Bq/kg), with an average value of (43.362Bq/kg). The highest value of the absorbed gamma dose rate (D_{γ}) was found in (S_{11}) station, which was equal to (43.92 nGy/h), while the lowest value of the absorbed gamma dose rate was found in (S_{26}) region which was equal to (26.54nGy/h), with an average value of (33.216nGy/h). The highest value of indoor annual effective dose rate ($AEDE_{\text{in}}$) was found in ($S_1, S_3, S_7, S_8, S_9, S_{10}, S_{11}$) stations, which was equal to (0.05mSv/y), while the lowest value of indoor annual effective dose rate ($AEDE_{\text{in}}$) was found in ($S_5, S_{26}, S_{27}, S_{30}, S_{37}$) stations which was equal to (0.03 mSv/y), with an average value of (0.04 mSv/y). The highest value of outdoor annual effective dose rate ($AEDE_{\text{oo}}$) was found in (S_{11}) station, which was equal to (0.22mSv/y), while the lowest value of outdoor annual effective dose rate was found in (S_{26}, S_{30}) stations which was equal to (0.13mSv/y), with an average value of (0.163mSv/y). The highest value of internal hazard index (H_{in}) was found in (S_{11}) station, which was equal to (0.35), while the lowest value of internal hazard index was found in (S_{26}) station which was equal to (0.2), with an average value of (0.255). The highest value of external hazard index (H_{ex}) was found in (S_{11}) station which was equal to (0.25), while the lowest value of external hazard index was found in (S_{31}) station which was equal to (0.15), with an average value of (0.186).

Table 2: Values of ^{226}Ra , ^{232}Th and ^{40}K hazard indices for soil samples from Al-sindbad land in Basra governorate

Number of samples	Ra _{eq} Bq/kg	H _{ex}	H _{in}	D _y nGy/h	AEDE _{oo} mSv/y	AEDE _{in} mSv/y
S ₁	57.74	0.22	0.28	38.3	0.19	0.05
S ₂	30.72	0.16	0.22	29.14	0.14	0.04
S ₃	56.78	0.22	0.33	40.14	0.2	0.05
S ₄	40.26	0.18	0.24	32.96	0.16	0.04
S ₅	39.98	0.16	0.22	28.45	0.14	0.03
S ₆	47.65	0.2	0.28	36.03	0.18	0.04
S ₇	60	0.24	0.34	42.09	0.21	0.05
S ₈	59.6	0.24	0.33	42.05	0.21	0.05
S ₉	49.8	0.21	0.3	37.25	0.18	0.05
S ₁₀	60.31	0.23	0.33	41.61	0.2	0.05
S ₁₁	65.48	0.25	0.35	43.92	0.22	0.05
S ₁₂	61.36	0.24	0.34	42.53	0.21	0.05
S ₁₃	42.02	0.18	0.29	33.6	0.16	0.04
S ₁₄	39.59	0.25	0.25	31.9	0.16	0.04
S ₁₅	37.57	0.17	0.24	31.32	0.15	0.04
S ₁₆	44.85	0.18	0.24	32.01	0.16	0.04
S ₁₇	43.8	0.19	0.25	33.25	0.16	0.04
S ₁₈	50.54	0.2	0.27	36.07	0.18	0.04
S ₁₉	39.59	0.18	0.24	32.54	0.16	0.04
S ₂₀	39.58	0.17	0.23	30.57	0.15	0.04
S ₂₁	42.82	0.18	0.24	32.67	0.16	0.04
S ₂₂	37.32	0.17	0.23	30.33	0.15	0.04
S ₂₃	39.25	0.18	0.24	31.77	0.16	0.04
S ₂₄	37.14	0.17	0.23	30.79	0.15	0.04
S ₂₅	44.67	0.18	0.26	33.01	0.16	0.04
S ₂₆	31.31	0.15	0.2	26.54	0.13	0.03
S ₂₇	34.7	0.15	0.22	28.03	0.14	0.03
S ₂₈	41.16	0.18	0.24	32.02	0.16	0.04
S ₂₉	40.26	0.17	0.23	29.82	0.15	0.04
S ₃₀	34.51	0.15	0.21	27.5	0.13	0.03
S ₃₁	34.36	0.16	0.23	30.1	0.15	0.04
S ₃₂	38.42	0.17	0.24	31.81	0.16	0.04
S ₃₃	36.39	0.16	0.22	29.48	0.14	0.04
S ₃₄	38.82	0.17	0.22	30.94	0.15	0.04
S ₃₅	45.21	0.19	0.26	34.33	0.17	0.04
S ₃₆	35.07	0.16	0.23	30.07	0.15	0.04
S ₃₇	33.56	0.15	0.21	28.16	0.14	0.03
S ₃₈	39.34	0.18	0.24	32.01	0.16	0.04
S ₃₉	44.74	0.19	0.25	33.23	0.16	0.04
S ₄₀	38.21	0.17	0.24	30.33	0.15	0.04
Average	43.362	0.186	0.255	33.216	0.163	0.040
Max	65.48	0.25	0.35	43.92	0.22	0.05
Min	30.72	0.15	0.2	26.54	0.13	0.03

4-Comparison of This work with other studies

A comparison of the values obtained in the present work with other literature data are shown in Table 3 and shows the activity concentration of are well within the national and world average values as presented in the UNSCEAR

Table (3):Comparison of radionuclide's concentrations (Bq/ kg) for soil samples of present study with other data

<i>Country</i>	^{226}Ra (Bq kg ⁻¹)	^{238}U (Bq kg ⁻¹)	^{232}Th (Bq kg ⁻¹)	^{40}K (Bq kg ⁻¹)
Present study	26.11	1.35	10.16	360.55
KENYA _[16]		52.3±4.2	61.9±3.9	1383.6 ±49.1
Turkey _[17]		25 ±14	50± 27	400
Basrah/Iraq _[18]	84.0±7.7Bq kg ⁻¹		8.2±1.0	315±9
All India _[19]		30.9	60.6	551.5

4. CONCLUSIONS

After describing the treatment and samples preparation, the data obtained of the specific activity of ^{226}Ra , ^{238}U , ^{232}Th and ^{40}K for soil samples in the studied region in Sindebad landin Basra governorate , The reason for the disparity in the values of radiant elements in this study is the result of the phenomenon of tides, which carry the water coming from the Gulf with Plankton and mud, which are deposited in the island over a long period of time past but the rate of results in general is lower than the value of the global limit which is equal to(33Bq/kg)(35 Bq/kg), (30 Bq/kg), (400 Bq/kg), respectively [20].The main sources of external radiation exposure are Uranium and Thorium, their decay products and ^{40}K . The internal exposure is due to radon and its radioactive daughters, present in the environment, which has the maximum contribution towards the average effective dose received by human beings .Current results have shown that radium equivalent activity values, absorbed gamma dose rate, annual effective dose rate AEDE_{oo} and annual effective doses AEDE_{in}, hazard indices(Hin) and (Hex) for the soil samples in the studied region in Sendebad landwere lower than the value of the global limit which is equal to (370Bq/kg),(55 nGy/h), (1 mSv/y), (1 mSv/y), (1)and (1), respectively [20]. The levels of results in present study confirm the absence of any unusual nuclear activities within the region. Because of the absence of contaminants and nuclear plants to manufacture radioactive material is an important factor in non-polluting the area. Thelevels of result confirm the absence of any unusual nuclear activities within the region. Because of the absence of contaminants and nuclear plants to manufacture radioactive material is an important factor in non-polluting the area.

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