

Natural Radioactivity Measurements of Soil Samples from Al-Iraqia University New Location in North Baghdad

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Abstract

Gamma ray spectroscopy technique with detector of high purity germanium (HPGe, 30% efficiency, energy separation 2.2keV at 1332keV for Co-60 isotope) connected to GINE-2000 program, has been used to measure the specific activity of ten soil samples taken from the new location of Al-Iraqia University 30 km north to Baghdad. Results have shown that the average specific activity of Pb-214, Bi-214 nuclides, as an equivalent to the U-238 specific activity is 15.432 ± 0.936 Bq/kg and 14.654 ± 1.33 Bq/kg for the (Ac-228, Ti-208) as an equivalent to the Th-232. On the other hand, the average specific activity of K-40 was 772.530 ± 0.87 Bq/Kg and (6.952 ± 0.79) Bq/kg for CS- 137 isotope. An agreement has been found between the present results and the allowable lower limit values considered by the IAEA for specific activity.

Keywords: Natural Radioactive, Gamma ray, germanium detector, Average specific activity.

Introduction

Many new colleges and universities were established at different locations in Iraq in order to keep up to the rapid development in science and technology over world. Amongst, Al-Iraqia University have established three new colleges, they are College of Education, College of Agriculture, and College of Veterinary Medicine. The location of the College of Education is 30km northern to Baghdad on the Baghdad-Mosul main road with an area of 97500 m². Across this area, several high-tension towers (132kV) were located after removing a brick factory. Therefore, the soil of this location was tested to ensure that it does not include any radioactive pollution.

One of the radioactive nuclides existing in the soil that considered the most important source of natural exposure to radiation are uranium (U-238 and U-235) and thorium (Th-232) series in addition to potassium (K-40), which individually exists in nature, while the most dangerous industrial source of radiation is cesium (Cs-137)[1]. The radiation background of these sources in the soil samples is determined by measuring their concentrations in these samples.

The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) has determined in its publications the allowed limits of natural radiation and mentioned that the optimum rate

of typical radioactive of uranium or thorium in soil is 40 Bq/kg [2], whereas the existence of uranium in environment is estimated by a typical radioactivity of 1-46 Bq/kg in soil [3].

Uranium exists in nature as oxides (UO₂ and UO₃) or combined with other elements to form carbon or silicon compounds. The U-238 series are represented by 18 isotopes ranging in their half lifetimes from seconds to hundred thousands of years to end as the stable isotope Pb-206[4]. Amongst most important components of these series are the isotopes Ra-226, Rn-222, Po-218 and Bi-214.

Thorium exists in nature combined with other elements to form different minerals such as thorite and its typical radioactivity in soil is estimated by 25.9 Bq/kg according to the publications of UNSCEAR, which determine the allowed limit by 40 Bq/kg. Thorium series (Th-232) includes 12 isotopes such as isotopes of actinium, thallium and radiative thoron gas [5], with half-life ranging from seconds to hundreds of years to end as the stable isotope Pb-208.

The radioactive isotope of potassium K-40 is available with 0.01178% and featured with a single line of gamma ray of energy 1460 keV. This isotope is permanently present in soil with a concentration of 3 ppm in the earth crust. The average radioactivity of this isotope in nature is about 31500 Bq/kg [6].

Experimental Part

Ten different points uniformly distributed over an area of 97500 m² were determined, as shown in Fig.(1). The location old brick factory and paths of high-tension power were taken into account. The surface soil was scrapped to depth of 15-20cm and samples were taken, kept in plastic vessels and assigned. These samples were dried by sun exposure for 4-5 days then milled and sieved by a 200µm sieve as this size is comparable to the average size of aerosols. Gravels and plant roots were removed from samples those left for 5 days for homogeneity. Certain amount of each sample was washed with a diluted HCl, rinsed in distilled water and placed in a Marneli pot for measurements.

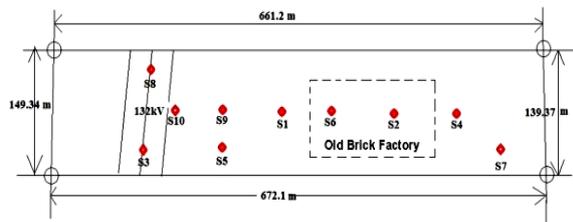


Fig. (1) The area from which the samples of this study were taken.

Gamma ray spectroscopy system was employed using a high-purity germanium detector (HPGe) with 30% efficiency and 2.2keV resolution power at energy of 1332keV from a Co-60 source. This system was calibrated by using Eu-152 source with the same geometry of Marneli pot and experimental conditions after shielding the detector with a lead shield to reduce the radiative background [7,8], which was calculated to be extracted from the typical mean value of the studied sample. Then, the spectrum of gamma ray was recorded to determine the typical mean radioactivity for each sample after maintaining the detection time at 2700 seconds and applying the following equation [9]:

$$dps = \frac{cps}{\epsilon \cdot w \cdot I_{\gamma}} \dots\dots\dots (1)$$

where cps is the peak area of the selected energy, ε is the detector efficiency at the selected energy, I_γ is the relative intensity of gamma ray from tables, and w is the weight of sample.

Results and Discussion

The typical radioactivity of Bi-214 and Pb-214 isotopes was considered at energies of 352 and 609 keV, respectively, as equivalent to that of U-238 by choosing the higher value. Similarly, the typical radioactivity of Ac-228 and Tl-208 isotopes was considered at energies of 583 and 911 keV, respectively, as equivalent to that of Th-232 by choosing the higher value. Additionally, the typical radioactivity of K-40 and Cs-137 isotopes was calculated at energies of 1460.8 and 661.6 keV, respectively. The latter (Cs-137) is considered as an industrial source.

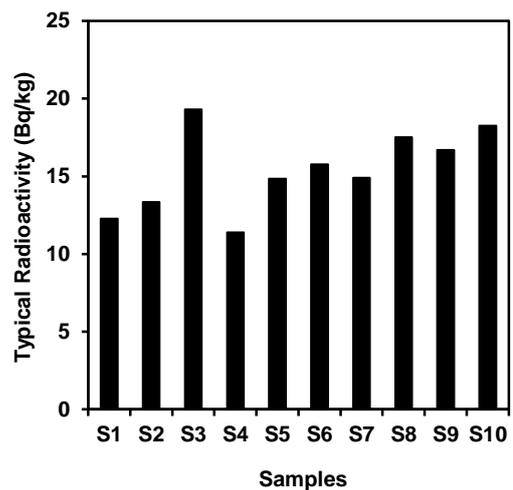


Fig. (2) Specific activity of U-238 equivalent for soil samples taken from Al-Iraqia University location in Baghdad.

Table (1) shows the typical radioactivity for the soil samples and demonstrates in Figs. (2-5), one can see that the maximum value of Pb-214 and Bi-214 isotopes was 19.301±0.225 Bq/kg in sample S3, which corresponds to the sample taken from the soil directly below the high-tension lines. The minimum value was 11.393±1.925 Bq/kg in sample S4 from a point near the location of old brick factory away from high-tension lines. The overall average value for U-238 is 15.432±0.936 Bq/kg. There was observed difference in the results that may be attributed to the locations near the high-tension lines in addition to the fact that the bismuth isotope emits positively-charged alpha particle, which is affected by the electric field.

The maximum value of typical radioactivity of Ac-228 and Tl-228 was

18.396±1.427 Bq/kg in sample S5 taken from point located at 110m from the high-tension lines towards the location of old brick factory. The minimum value was 12.405±1.229 Bq/kg in sample S3 and the overall average value for Th-232 is 14.654±1.33 Bq/kg. The maximum value for individual K-40 nuclide in nature was 918.978±12.006 Bq/kg in sample S7 away from both old brick factory and high-tension lines while the overall average value was 772.530±0.87 Bq/kg.

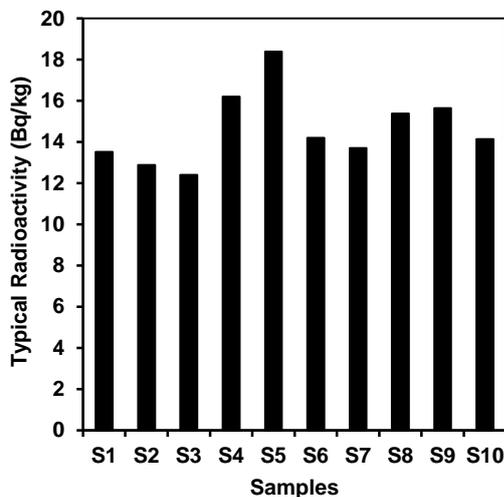


Fig.(3) Specific activity of Th-232 equivalent for soil samples taken from Al-Iraqia University location in Baghdad.

For Cs-137 nuclide, the maximum value was 11.808±0.967 in sample S4 at point near the factory and away from the high-tension lines, while the minimum value was 3.400±0.738 Bq/kg in sample S10 at point directly below the high-tension lines towards the factory as the overall average value is 6.952±0.79 Bq/kg.

The average specific activity in samples S5 and S8 for the Cs-137 isotope was below detection level (B.D.L). The obtained results were different according to the different locations from which the soil samples were taken and this is attributed to the type of rocks forming this soil. Comparing these results with some world studies, the average radioactivity of equivalents to U-238, Th-232 and K-40 in this study is lower than that in Bangladesh, Vietnam, Taif in Saudi Arabia, Eastern Siberia and Yemen [10]. As well, results of this study were found comparable to those of local studies [11]. In general, these results are

ranging at the minimum values considered by the IAEA.

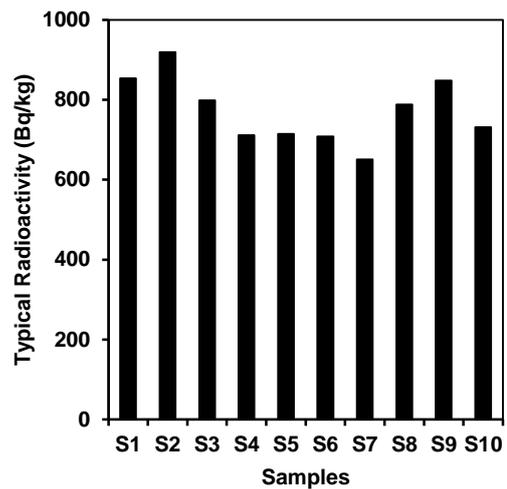


Fig.(4) Specific activity of K-40 equivalent for soil samples taken from Al-Iraqia University location in Baghdad.

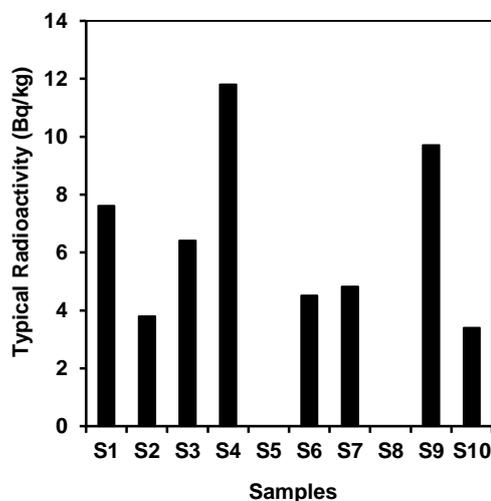


Fig.(5) Specific activity of Cs-137 equivalent for soil samples taken from Al-Iraqia University location in Baghdad.

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الخلاصة

أخذت عشرة نماذج من تربة الموقع الجديد لبنائية الجامعة العراقية الواقعة على بعد 30 كم شمال بغداد وقيست الفعالية النوعية لهذه النماذج باستخدام تقنية مطيافية اشعة كاما بأستخدام كاشف الجرمانيوم عالي النقاوة (HPGe) (ذي كفاءة 30% وفصل طاقى 2.2keV عند الطاقة 1332keV لنظير ((Co-60)) ومنتصلة بمحل متعدد القنوات المجهزة ببرنامج (GINE-2000). أشارت النتائج الى إن معدل الفعالية الإشعاعية النوعية لنويدات الـ (Pb-214, Bi-214) كمكافئ للفعالية النوعية لـ (U-238) هو $(15.432 \pm 0.936 \text{Bq/kg})$ و $(14.654 \pm 1.33 \text{Bq/kg})$ بالنسبة الى (Ac-228, Ti-208) كمكافئ للفعالية النوعية لـ Th-232، اما معدل الفعالية النوعية الى (K-40) فكان بمقدار $(772.530 \pm 0.87 \text{Bq/Kg})$ و $(6.952 \pm 0.79 \text{Bq/kg})$ بالنسبة الى نظير (Cs-137). اظهر معدل النتائج توافق مع قيم الحدود الدنيا المعتمدة لدى الوكالة الدولية للطاقة الذرية IAEA.

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