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Natural Radioactivity and Hazard Indices of Soil Sample in Al-Dura thermal Power Plant in the Southern of Baghdad-Iraq

Leena A. Hattab*
Department of Astronomy and Space, College of Science, University of Baghdad, Baghdad, Iraq

Abstract

The presence of natural radioactivity in soil and other materials results in internal and external exposure in twelve samples at Al_Dura Heating generator at south of Baghdad using NaI(Ti) detector .Therefore, it is desirable to determine the concentration of naturally occurring radionuclide's^{238} U ^{232}Th and ^{40} K,.. natural radioactivity and associated radiation hazard in some soil samples. The natural radioactivity due to the presence of ^{238} U ^{232}Th and^{40} K in soil samples was measured by gamma spectrometry using NaI(Tl) scintillation well-shaped detector. In this context, soil samples were collected from thirty different locations of southern Al-Dura thermal Power Plant.Radium equivalent activities were calculatedfor the analyzed samples to assess radiation hazards arising due to the presence of these radionuclide's in the samples most of the calculated radium equivalent activities are lower than the limit set in the OECD report at 370 Bq/K.The measured representative level index values for the investigated samples varied in 1.035- 0.375 & 0.630- 0.1380 Bq/kg the range external and internal hazard index (H_{ex},H_{in}) , The radiation hazard indices of soilwas also lower than the maximum suggested global value the values of the H_{ex} and H_{in} indices must be less than unity (<1) for the radiation hazard to be negligible the specific dose rates indoor (D) and the annual effective dose (DE) due to gamma radiation from building materials was calculated.The value of the representative gamma index ($I_{\gamma r}$) for the all soil samples were greater than the unity (>1).

Keywords: Soil, natural radioactivity, NaI(Tl) Detector,, gamma radiation, absorbed dose

النظائر المشعه طبيعيا ومعاملات الخطورة لبعض عينات الترب من محطة الدورة الحرارية جنوب بغداد–العراق

لينا عواد حسين*
قسم علوم الفلك والفضاء، كليه العلوم، جامعة بغداد، بغداد، العراق

الخلاصة

تمت دراسة النظائر المشعة طبيعيا والنظائر المشعة المحسنة صناعيا لاثنتي عشر عينه من التراب المجموعة من محطة الدورة الحرارية الواقعة جنوب بغداد باستخدام كاشف ايوديد الصوديوم الفعاليه الاشعاعية وهي السلاسل الثلاث الموجوده في الطبيعه ^{238} U ^{232}Th and ^{40} K بالاضافه الى ^{137} Cs وكان معدل تركيز الفعاليه الاشعاعية في عينات التراب لا تزال أقل من المتوسط العالمي 50 بيكريل / كغم لU^{238} وTh^{232}، ولكن أعلى من ذلك بكثير في K^{40}، مقارنة مع المعدل العالمي والذي هو 500 بيكريل / كغم. بالاضافة الى الحسابات السابقة تم حساب معاملات الخطورة وقد تبين ان معاملات الخطورة لعينات التراب اقل من المعدل الموجود عالميا والذي يقدر ب 1وهذا يشمل معامل الخطورة الداخلي والخارجي و معامل الخطورة للتعرض لاشعة كاماوالذي هو اعلى من المعدل المذكور عالميا والذي يقدر ب 1 في هذه الحالة يجب معالجة النظائر المشعة طبيعيا الصادرة من هذه المحطة.

*Email: leenaawad33@yahoo.com

Introduction:

Naturally occurring radioactive materials is a widespread substance that can be found everywhere in the environment including soil, rocks, water, air and also tissues of living things. There are no ways to avoid the presence of natural radionuclide since it presence from the formation of earth. Sand is one of the main components in building constructions are known to contain with naturally occurring radioactive materials. Sands are mineral deposits formed through weathering and erosion of either igneous or metamorphic rocks [1]. Natural radioactivity in soil contributed radiation dose to dwellers that originate from ^{238}U,^{232}Th and^{40}K.As these radionuclide's (^{238}U,^{232}Th and^{40}K) are not uniformly distributed, the knowledge of their distribution in soil, sand and rock play an important role in radiation protection and measurement[1,2]. The present work investigates the concentrations of radioisotopes such as (^{238}U,^{232}Th and ^{40}K) in soil samples from Al-Dura thermal power plant , also this study is estimate the radiological hazard, the radium equivalent activity, the external hazard index, the absorbed dose rate, and the effective dose rates were calculated and compared with internationally approved values.

The radiological survey is important for each country, to establish a data base for environmental purposes, and for future variation in radiation level due to one reason or another. The radiological impact from the natural radioactivity is due to radiation exposure of the body by gamma-rays and irradiation of lung tissues from inhalation of radon and its progeny. From the natural risk point of view, it is necessary to know the dose limits of public exposure and to measure the natural environmental radiation level provided by ground, air, water, foods, building interiors, etc., to estimate human exposure to natural radiation sources Low level gamma-ray spectrometry is suitable for both qualitative and quantitative determinations of gamma-ray-emitting nuclides in the environment.

The concentration of radioelement in building materials and its components are important in assessing population exposures, as most individuals spend 80% of their time indoors. The average indoor absorbed dose rate in air from terrestrial sources of radioactivity is estimated to be 70nGy/h[1].

Material and methods

Soil samples were collected from Al-Dura thermal power station in the south of Baghdad .the samples were dried for 24 h in electrical oven at 110 °Cwere further powdered, homogenized. The dried samples were grounded with mortar and pestle and then allowed to pass through a 100- mesh sieve. Sample of 1kg dry-weight were packed in air tight cylindrical plastic container which is of the detector geometry, and stored for a period of four weeks before counting, so that secular equilibrium can be attained, after attained of secular equilibrium the samples were subjected to gamma -ray spectrometric analysis.

Gamma spectrometric analysis

Gamma spectroscopy systems that use NaI(Ti) as a detector material are considered as practical, in-situ measurement systems [2] due to their room temperature operation. The electrons generated by the radiation interaction are transferred into photoelectrons indirectly to generate the electrical pulses. The gamma-ray photons deposit their energy in the scintillator (a florescence material) resulting in the raising of atoms to exited states. The energy to excite electrons from the valence band, which is generally full, to the empty conduction band across the energy gap is about 4 eV in NaI[3]. Eventually, the excited atoms lose their energy by emitting visible photons and the electrons drop back into the valence band. The visible photons emitted following this de excitation hit a photosensitive surface and photoelectrons are generated. Electrical pulses are formed by multiplying and accelerating the photoelectrons using a photomultiplier tube. Self-absorption of visible photons in a pure NaI crystal can occur. In order to reduce this effect, and to increase the probability of transmission of visible photons, small amount of impurities, called "activators" are added to the crystal such as the element thallium (Tl).

Adding activators to a pure NaI crystals to form NaI(Tl) increases the wavelength of the maximum emission of visible photons from 303 nm to 410 nm reducing the self-absorption of the scintillation light within the crystal [3].

Sample analysis

The samples were analyzed using a thallium activated Canberra vertical high purity 3”x 3” Sodium iodide (NaI(TI)) detector connected to ORTEC 456 amplifier.The detector was connected to a computer program MAESTRO window that matched gamma energies to a library of possible isotopes. The cylindrical plastic containers holding the samples were put to sit on the high geometry 7.6cm x

7.6cm NaI(TI) detector. High level shielding against the environmental background radiation was achieved by counting in the Canberra 100mm thick lead castle. The ^{232}Thconcentration was determined from the average concentrations of ^{212}Pb (238.6 keV) and ^{228} Ac (911.1 keV) in the samples the average concenration of ^{214}Pb (351.9 keV) and decay product of ^{40}K (1460 keV). The energy resolution of the detector using Cs-137 from International Atomic Energy agency (IAEA) is 8% at 662keV Cs-137 line, while the activity of the standard at the time of calibration is 25.37kBq.The background spectrum measured under the same conditions for both the standard and sample measurements, were used to correct the calculated sample activities concentration [4,5].

Theoretical Concept

Radiation Hazard Indices Calculation

Different known radiation health hazard indices analysis have been use in radiation studies to arrive at a better and safer conclusion on the health status of exposed or irradiated person and environment in recent studies .

1) Radium Equivalent Activity (Ra_{eq})

Radium equivalent (Ra_{eq}) is a common index used tocompare the specific activities of materials containing ^{226}Ra , ^{232}Thand ^{40}K by a single quantity, which takes into account the radiation hazards associated with them.The activity index provides a useful guideline in regulating the safety standard dwellings.The radium equivalent activity represents a weighted sum of activities of the above mentioned natural radionuclide's and is based on the estimation that 1Bq/K of ^{226}Ra ,0.7 Bq/k ^{232}Th , and 13 Bq/k ^{40}K produce the same radiation dose rates

The radium equivalent activity index is given as:

Raeq(Bq/k) = A_{Ra}+(A_{Th}*1.43)+(A_k*0.077)

Where: A_{Ra}, A_{Th}, $A_k$are the radioactivity concentration of ^{226}Ra , ^{232}Th , ^{40}K [6,7]

2) External Hazard Index (Hex)

Many radionuclides occur naturally in terrestrial soils and rocks and upon decay, these radionuclides produce an external radiation field to which all human beings are exposed. In terms of dose, the principal primordial radionuclides are of activities of the above mentioned natural radionuclides are ^{226}Ra, ^{232}Thand ^{40}K Thorium anduranium head series of radionuclides that produce significant human exposure.

Hex(Bq/Kg) = A_{Ra}/370+A_{Th}/260+A_K/4810

3) Internal Hazard Index (Hin):

The internal hazard index is given as **Hin= A_{Ra}/185+A_{Th}/259+A_k/48104 Bq/K**

4) Representative Gamma Index (Iyr):

Gamma index have been used to estimate the γ- radiation hazard associated with the natural radionuclide in specific investigated samples. The representative gamma index

Iyr=A_{Ra}/150+A_{Th}/100+A_k/1500

Gamma index is also used to correlate the annual dose rate due to the excess external gamma radiation caused by superficial materials.

5) The absorbed gamma dose rate

The absorbed gamma dose rate in air at1 m above the ground surface for uniform distribution of radionuclides ^{238} U,^{232}Th and ^{40} K was computed on the basis of guide-lines provided by UNSCEAR . The conversion factors used to compute absorbed gamma dose rate (D) in air per unit activity concentration in (1Bq/kg)

D= [0.604*Ath+0.462 *A_{Ra}+0.0417*Ak] nGy h-1

Where: ARa, ATh, Ak are the radioactivity concentration in 226Ra, 232 Th, 40K respectively [8-10].

Results and Discussion

Table-1 presents the three (^{226}Ra , ^{232}Th , ^{40}K) natural radionuclide isotopes present in the power station ,The average range of (^{226}Ra , ^{232}Th , ^{40}K) are **72.7588-14.0669**, **40.239-2.62428**, **3786.22-674.462**respectively.and**63.5022-3.87192**Bq/k for Cs-137.

Table 1-Concentration of natural radionuclide for the investigated samples of soil for NORM and artificial isotopes

S.No	K-40 Bq/kg	U-238 Bq/kg	Th- 232 Bq/kg	Cs-137 Bq/kg
L1	3786.22	22.7754	48.4862	38.2564
L2	1332.2	50.3578	13.71318	52.526
L3	1433.828	35.469	8.56744	28.3488
L4	1181.866	56.9544	13.06988	43.6866
L5	1571.668	54.8318	9.1078	45.837
L6	1842.77	34.4598	3.85924	63.5022
L7	1576.614	14.0669	4.60534	48.9196
L8	1286.692	51.2318	19.70778	37.154
L9	740.772	28.1338	2.72716	30.676
L10	674.462	17.9998	2.62428	3.87192
L11	1103.83	47.6734	15.43682	45.2382
L12	877.606	39.4956	22.3576	39.4336
L13	704.87	72.7588	40.239	60.508

Table 2- Represented the**$Ra_{eqBq/kg}$**Dose Rate, Hazard indices in all studied samples

S.N	$Ra_{eqBq/kg}$	Dose Rate nGy/h	$H_{ex\ Bq/k}$	$H_{inBq/kg}$	Iyr
L1	383.649606	197.6932736	1.035196445	0.410062554	3.160844667
L2	172.5470474	87.10080432	0.465809819	0.399361057	1.3609838
L3	158.1251952	81.35203936	0.426906994	0.287373096	1.278019733
L4	166.6480104	83.49095252	0.449909767	0.435502719	1.298305467
L5	188.87439	96.3719584	0.509974158	0.414874253	1.504402
L6	181.8718032	95.09491756	0.491090091	0.271308581	1.496837733
L7	142.0518142	75.02533696	0.383509873	0.13958736	1.190908733
L8	178.4892094	89.22764712	0.481767012	0.427091842	1.3964178
L9	89.0730828	45.53521264	0.240533027	0.203990985	0.708678267
L10	73.6860944	38.02603812	0.198962283	0.138076053	0.5958828
L11	154.7429626	77.37866108	0.417705898	0.384278742	1.208077533
L12	139.04263	68.3471278	0.375190104	0.354538862	1.071950667
L13	184.57556	87.3120006	0.49795341	0.630514712	1.357362

Radium equivalent activities were ranged from **383.649606-89.0730828** Bq/K for the analyzed samples to assess radiation hazards arising due to the presence of these radionuclide's in the samples Most of the calculated radium equivalent activities are lower than the limit set in the OECD report at 370 Bq/kg. The measured representative level index values for the investigated samples varied from **1.035- 0.375 & 0.630- 0.1380 Bq/kg** the range External and internal hazard index (H_{ex},H_{in}) , The radiation hazard indexes of soil were also lower than the maximum value suggested The values of the H_{ex} and H_{in} indices must be less than unity (<1) for the radiation hazard to be negligible the specific dose rates indoor (D) and the annual effective dose (DE) due to gamma radiation from building materials was calculated. The value of the representative gamma index ($I_{\gamma r}$) for the all soil samples is about between **3.160844667-0.5958828**Bq/kg were greater than the unity (>1). In this case.

Conclusions

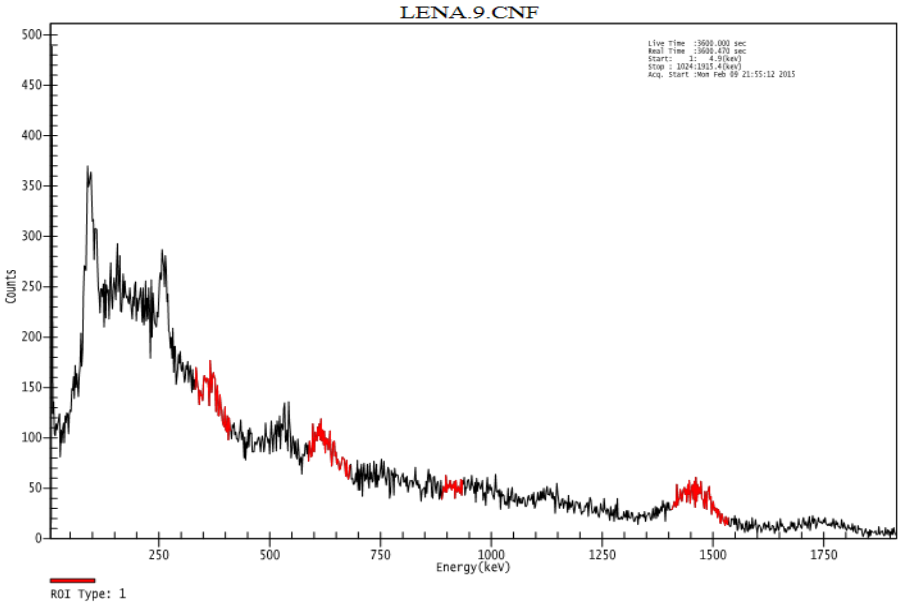
The gamma spectroscopy method was used for assessment of the U-238 and Th-232 series and K-40 concentration in many soil samples collected from **Al-Dura thermal Power Plant** in the southern of Baghdad city the average activity concentrations of ^{238}U,^{232}Th and ^{40}K in soil samples were found to be(40.47,15.73and2.094)Bq/kg respectively. On the whole the radionuclide's concentrations were still below the global average of 50 Bq/kg, for U-238and , Th-232 but is much higher in K-40 because the global average is about 500 Bq/kg for K-40.[11,12].The concentrations of these natural radionuclide's were compared with the reported data for other countries and were found significantly lower than the worldwide average as reported by United Nations Scientific Committee on the Effects of Atomic Radiation.this is due to the natuer of soil inside the station or due to the military strikes on the station in 1991.The measured activity in the soil samples ranged from **72.7588-14.0669**, **40.239-2.62428**, **3786.22-674.462**Bq/K ^{238}U ^{232}Th and^{40}K respectively.and**63.5022-3.87192**Bq/k for Cs^{137}.

Radium equivalent activities were calculated **383.649606-89.0730828** Bq/K for the analyzed samples to assess radiation hazards arising due to the presence of these radionuclide's in the samples Most of the calculated radium equivalent activities are lower than the limit set in the OECD report at 370 Bq/K.

The measured representative level index values for the investigated samples varied in **1.035196445- 0.375190104 and 0.630514712- 0.138076053 Bq/kg** the range External and internal hazard index (H_{ex},H_{in}) , The radiation hazard indexes of fly ash were also lower than the maximum value suggested The values of the H_{ex} and H_{in} indices must be less than unity (<1) for the radiation hazard to be negligible the specific dose rates indoor (D) and the annual effective dose (DE) due to gamma radiation from building materials was calculated. The value of the representative gamma index ($I_{\gamma r}$) for the all soil samples is about between **3.160844667-0.5958828**Bq/kg were greater than the unity (>1). In this case, treatments to the NORM released from that stations must be done.

From this research, we deduce the following:

The evaluation of radiation hazard indices and The values obtained when compared with the various world permissible values were found to be below the standards for such environment and as such exposure to the drilling mud by the drillers and other workers will pose no significant health threat to human lives and the environment is said to be radio logically hazard safe [12].



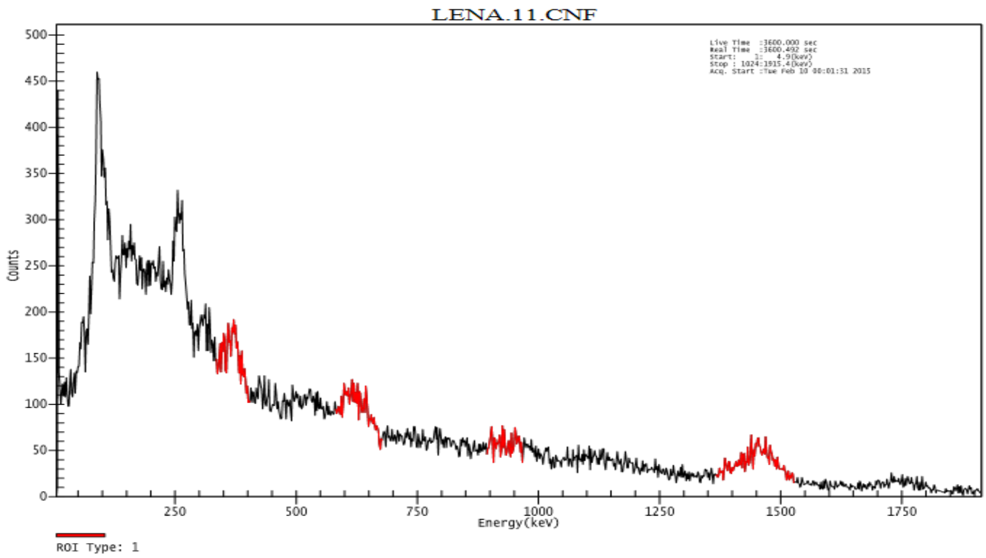


Figure 1- Activity concentration of soil samples

The study area

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