Measurement of Radioactivity for Radium^{226} Isotopes in some Soil Samples from Different Regions in Karbala Governorate using Gamma Ray Spectrometry

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Abstract
In this work the calculation of the concentration of radionuclide Ra^{226} in some samples of soil in governorate of Karbala have been done by gamma-ray spectroscopy NaI(TL) scintillation detector. The range of Ra^{226} activity was found from 11.41 ± 3.37 to 99.6 ±16.8 Bq/Kg. The concentrations of radon gas in the air was determined as well as the activity concentrations of Ra^{226} in vegetables. The doses resulting from the consumption of vegetables and those were coming from the inhalation of radon gas were estimated using some of mathematical equations , also the mean value of the activity concentrations of Ra^{226} inside the soil samples that measured in the present work were compared with the values of the other countries in the world and it is found that within the permitted limits.

الخلاصة
تم في هذا البحث حساب تركيز النشاط الإشعاعي لنويد الراديوم 226 في بعض نماذج التربة في محافظة كربلاء وذلك باستخدام كاشف طيف أشعة كاما ألوميضي NaI(TL) , ولوحظ أن النشاط الإشعاعي في هذه النماذج تتراوح من 3.37 ± 11.41 إلى ± 99.6 16.8 (Bq/Kg) . تم حساب تراكيز الرادون في الهواء إضافة إلى تراكيز الراديوم في الخضراوات وباستخدام بعض المعادلات الرياضية تم حساب الجرع الناتجة للراديوم 226من استهلاك الخضراوات والجرع الناتجة من استنشاق غاز الرادون 222 , وقد تم مقارنة معدل القيمة للنشاط الإشعاعي للراديوم 226 المقاسة في نماذج التربة مع قيم بقية بلدان العالم ووجدت أنها ضمن الحدود المسموحة بها.

Introduction
Studies on radiation levels and radionuclide distribution in the environment provide vital radiological baseline information .Such information is essential in understanding human exposure from natural and man made sources of radiation and necessary in establishing rules and regulations relating to radiation protection [Quindos et al ,2004] and [Ibrahim et al ,2006]. Measurements of natural radioactivity in soil have been performed in many parts of the world, mostly assessment of the dose and risk resulting from them [Rudge et al ,1993] , [Clouvas et al ,2001] , [Copplestone et al , 2001] , [Dowdall et al , 2004] and [El-Bahi et al , 2005].

The naturally occurring radionuclides present in soil include Ra^{226} , Th^{232} and K^{40} [Khan et al , 1998] . Gamma radiation emitted from those naturally occurring radioisotopes, called terrestrial background radiation , represents the main source of irradiation of the human body and contribute to the total absorbed dose via ingestion , inhalation and external irradiation [Steinhausler , 1992] . Calculations by [Beck , 1972] suggested that 50-80% of the total gamma flux at the earth´s surface arises from K^{40} , U^{238} and Th^{232} series in topsoil. Natural environmental radioactivity and the associated external exposure due to the gamma radiation depend primarily on the geological and geographical conditions and appear at different levels in the soils of each region in the world , Since the radionuclides are not uniformly distributed , the knowledge of their distribution in soils play an important role in radiation protection and measurement [Khan et al , 1994], also the radioactivity of soils is essential for understanding changes in the natural background [Sroor et al , 2001] and [Chiozzi et al , 2002] .

System of detection and analysis
In the present work using gamma spectrometer with a scintillation detector (3 x 3) inch NaI (TL) as shown in fig (1) that working at (750)volt with the efficiency of 60% . The viability of discrimination detector of energy in the limits (6.5-8.56)% for the energy values (0.662-1.332)Mev. The detector surrounded by lead shield to prevent the background radiation.

The radioactive sources (Cs^{137} , Na^{22} , Co^{60}) were used to calibrate the system and calculate the efficiency of the detector.

Collection and preparation of samples

(A) Collected six soil samples from different regions of the government of Karbala with a weight of two kilogram for each sample and set in bags , after then placed on each bag zone name for soil taken .Details of the soil samples examined are as follows.

1- Drying : All samples were dried by exposing them to sunlight for time period of (72) hour , in addition the dried samples exposing to air for a full day to ensure fully dry .

2- Grinding : The samples are grinding with using hand-mill and then used a sieve with a diameter of 2mm in order to obtain smooth samples.

(B) Create a system:

Account background radiation to subtracting from the value of the radioactivity for all preparation soil samples at the same period measured , after then the crushed soil were measured in Marinelli-type beakers with a production capacity of one kilogram with the time period of one hour.

Method of calculations

A – The magnitude of the concentration of Ra^{226} inside the soil was calculated by [Chung et al , 1989];

$CRa(n)= C(E_n) – B(E_n)/ m.f.t.P(E_n)$ **……………………..(1)**

Where

n : is the number of soil sample , 1,2,3…..etc

CRa(n) : is the radioactive concentration of Ra^{226} in soil sample (n) in (Bq/Kg) .

$C(E_n)$: is the net γ-counts above continuum at the characteristic energy (E_n) .

$B(E_n)$: is the background counts at (E_n) .

m : is the mass of the sample in (Kg) .

f : is the branching ratio of the γ-emission at the energy considered .

t : is the measuring live time in (sec) .

$P(E_n)$: is the absolute efficiency at energy (E_n) .

B – The formula that used to measuring the radioactive concentration of Rn^{222} in the air as follow (UNSCEAR,1988) ;

Firstly must be estimate the radioactive concentration of Rn^{222} inside the soil samples by ;

$Gs(n) = F_r . \rho . CRa(n)$ **………………. (2)**

Where

Gs(n) : concentration of radon gas inside the soil for sample(n) in (Bq/m^3) .

F_r : the constant of emission of Rn^{222} from the soil that is equal to (o.1) .

ρ : is the soil density that is equal to (1800 Kg/m^3) .

CRa(n) : is the radioactive concentration of Ra^{226} in soil sample (n) in (Bq/Kg).

Now we can calculate the concentration of Rn^{222} in the air by the below equation ;

$Ca(n)=Gs(n) (d_{soil} / D_{air})^{1/2}$ **……………. (3)**

Where

Ca(n) : is the concentration of Rn^{222} in the air for sample (n) in (Bq/m^3) .

Gs(n) : concentration of radon gas inside the soil for sample(n) in (Bq/m^3) .

d_{soil} : is the diffusion rate constant of Rn^{222} in the soil (0.5×10^{-4} m^2/sec) .

D_{air} : is the diffusion rate constant of Rn^{222} in the air (5 m^2/sec) .

C - : Expense of radioactivity in vegetables was determined by using the following equation (UNSCEAR ,1988 ; IAEA ,1996) ;

$C_n = A_n . CRa(n)$ **………………………..(4)**

Where

C_n : is the concentration of Ra^{226} in vegetables in (Bq/Kg) .
A_n : is the transfer coefficient of Ra^{226} from soil to Vegetables that is equal to (o.o4) ; (IAEA ,1990) .
CRa(n) : is the radioactive concentration of Ra^{226} in soil sample (n) in (Bq/Kg) .

D – The doses rates that coming from inhalation of radon gas and vegetables consumption was determined by using the below equation (IAEA , 1996)

Hp =Cp . Ip . DCF **……………….(5)**

Where

Hp : is the dose rate resulting from inhalation of radon gas or vegetables consumption in (sv/y) .
Cp : is the concentration of Ra^{226} in vegetables (Bq/Kg) or the concentration of Rn^{222} in the air (Bq/m^3) .
Ip : is the amount of consumption of vegetables in year (90Kg/y) and for air outside the home (600 m^3/y) ;(IAEA ,1990) .
DCF : is the dose conversion coefficient: for Ra^{226} equal to (2.8×10^{-7} sv/Bq) and for Rn^{222} equal to (1.3×10^{-9} sv/Bq);(UNSCEAR,1988) .

Results and Discussion

The Ra^{226} activity concentrations were measured for six soil samples that collected from different locations of Karbala governorate. Sampling locations are marked in Fig(2). The data of these study are given in table (1) . The activity concentrations of Ra^{226} in soil samples ranges from 11.41 ± 3.37 to 99.6 ± 16.8 with mean value of 55.3 Bq/Kg . From the results in table (1) appear the higher concentration of Ra^{226} in regions of Al-hur (1) and Al-Ibrahimia (1) , this is due to the natural state and creation of soil . The radioactive radon gas that arises from the disintegration of U^{238} and Th^{232} in the earth´s crust is considered the main source of exposure to ionizing radiation for humans that representing 40% of the annual accumulated dose (UNSCEAR,1993) , therefore the present study some of mathematical equations models are used to estimate the activity concentrations of Rn^{222} in the air with the activities of Ra^{226} that contents in vegetables , as well as the doses rates that results from the vegetables consumption and from inhalation of radon gas were considered, table (2) ,(3) and (4) consists of these estimated concentrations and doses values respectively . The data of the doses rates from the vegetables consumption and inhalation of radon gas that given in table (4) within the allowed limits that equal (1msv/y) [FAO.1977 , IAEA,1996] in all regions that selected in the present search .

Comparison of activity concentrations with other countries:

The mean value of activity concentrations of Ra^{226} in soil samples from studied area was compared with those from similar investigations in other countries and a summary results were given in table (5).

Conclusions

1- The present work developed that all soil samples that taken from all regions from the Kabala governorate have the Ra^{226} element with different activity concentrations.

2- The obtained values of natural radioactivity and γ-absorbed dose rates due to the activity concentrations of soil samples and in the air show that none of the studied samples is considered a radiological hazard.

3- Soils can be safely used in construction of buildings and exploits for the agriculture without posing any significant radiological threat to population .

4- It is important to point out that these values were not the representative values for the countries mentioned , but for the regions from where the samples were collected .

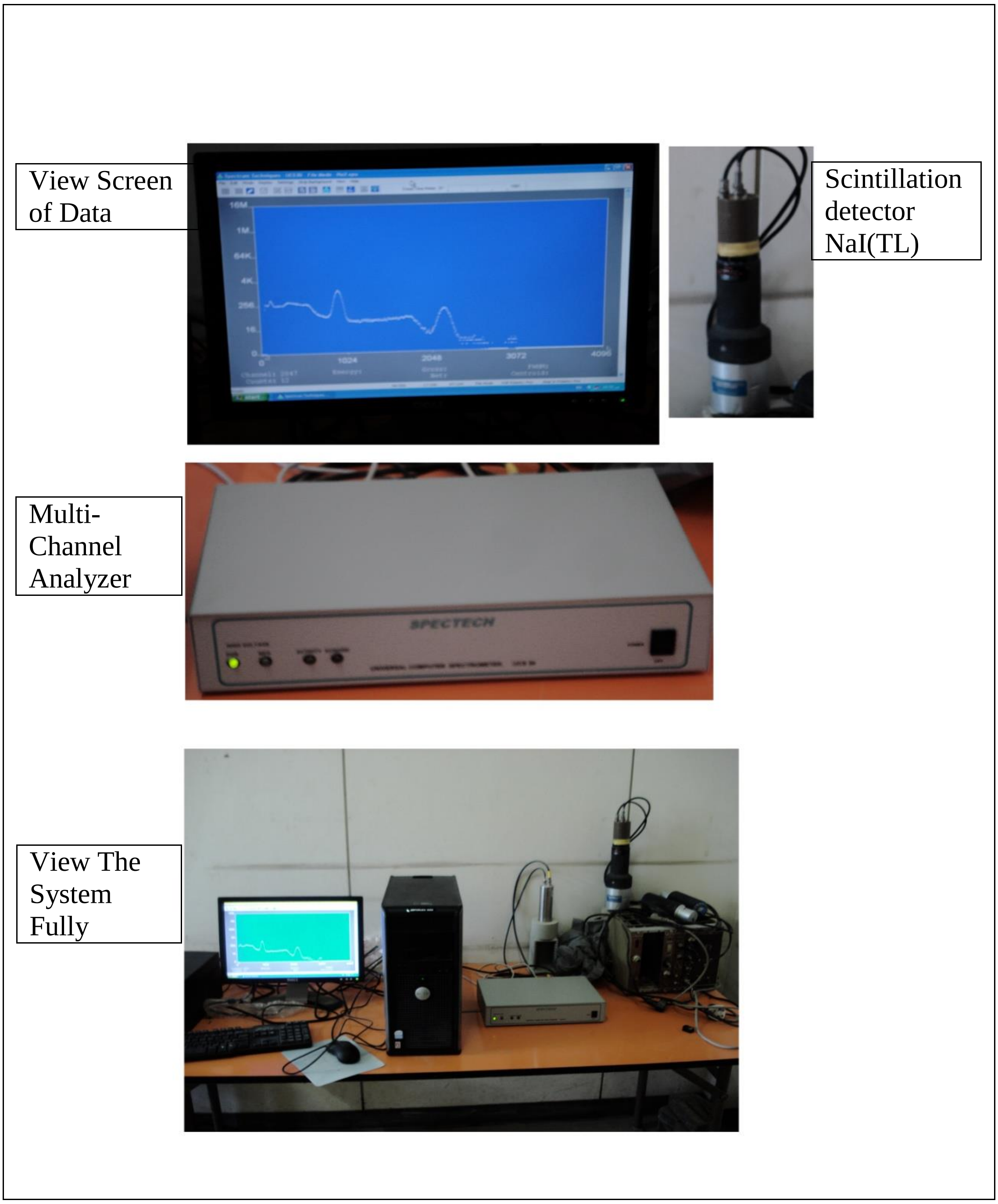

Fig (1) system of measurement

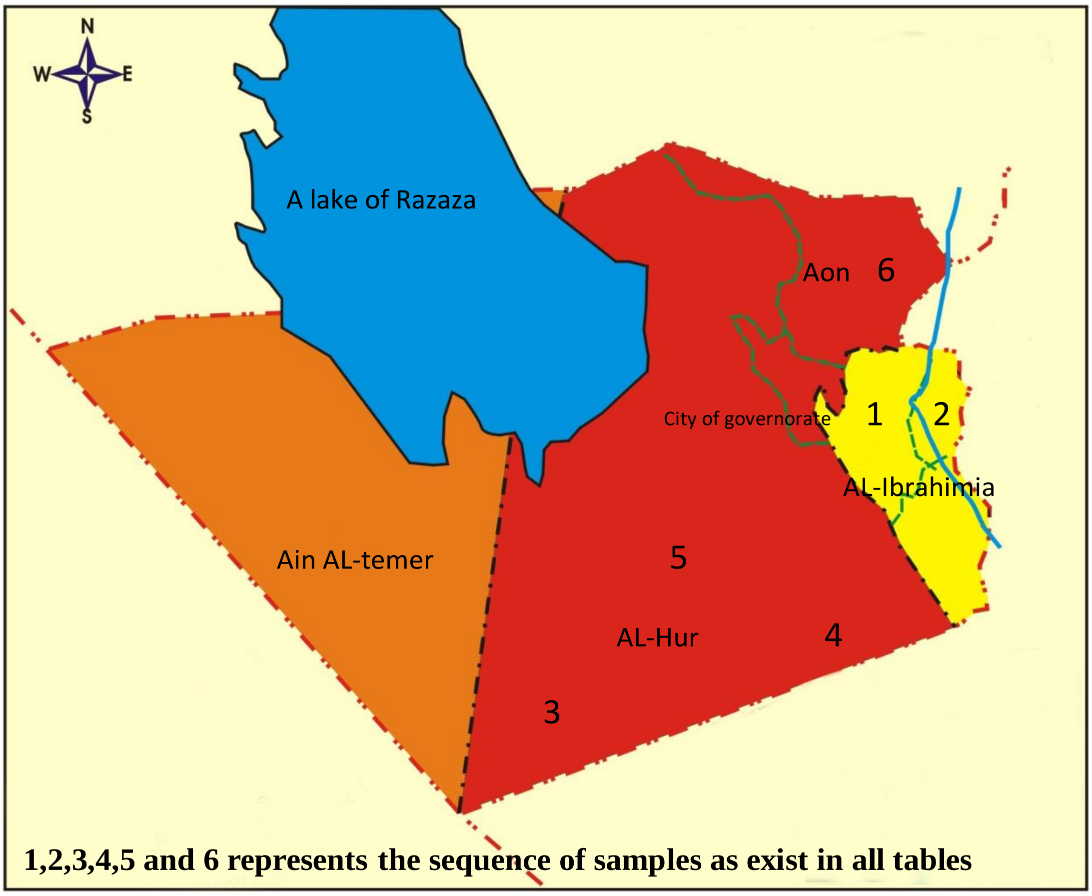

Fig (2) The sampling locations of six soil samples in the governorate of Karbala.

Table (1) the activity concentrations of Ra^{226} in soil samples(Bq/Kg).

Sequence	Zone name	Activity of Ra^{226}
1	Al-Ibrahimia (1)	93.2 ± 10.5
2	Al-Ibrahimia (2)	16.16 ± 4.01
3	Al-Hur (1)	99.6 ± 16.8
4	Al-Hur (2)	55.9 ± 16
5	Al-Hur (3)	55.7 ± 24.6
6	Aon	11.41 ± 3.37

Table (2) the activity concentrations of Rn^{222} in soil and in air (Bq/m^3).

Sequence	Zone name	Activity of Rn^{222} in soil	Activity of Rn^{222} in air
1	Al-Ibrahimia (1)	16776	53
2	Al-Ibrahimia (2)	2908.8	9.198
3	Al-Hur (1)	17928	56.69
4	Al-Hur (2)	10062	31.818
5	Al-Hur (3)	10026	31.7
6	Aon	2053.8	6.494

Table (3) the activity concentrations of Ra^{226} in vegetables (Bq/Kg).

Sequence	Zone name	Activity of Ra^{226}
1	Al-Ibrahimia (1)	3.7
2	Al-Ibrahimia (2)	0.64
3	Al-Hur (1)	3.98
4	Al-Hur (2)	2.24
5	Al-Hur (3)	2.23
6	Aon	0.45

Table (4) the doses rates resulting from consumption of vegetables(Ra^{226})and inhalation of Rn^{222} gas (msv/y).

Sequence	Zone name	Doses from vegetables	Doses from inhalation
1	Al-Ibrahimia (1)	0.093	0.041
2	Al-Ibrahimia (2)	0.016	0.0077
3	Al-Hur (1)	0.1	0.044
4	Al-Hur (2)	0.056	0.024
5	Al-Hur (3)	0.056	0.024
6	Aon	0.011	0.005

Table (5) : Comparison of radioactivity levels(mean values) of Ra^{226} in soil samples under investigation with those in other countries.

Countries	Mean values (Bq/Kg)	References
Iraq (Karbala)	55.3	Present work
United states	40	[UNSCEAR,2000]
Aqaba (Highway)	63	[Al-Jundi et al ,2003]
Switzerland	40	[UNSCEAR,2000]
Bulgaria	45	[UNSCEAR,2000]
South districts	42	[Chowdhury et al ,2006]
Pakistan (Lahore)	25.8	[Akhtar et al , 2005]
Hong Kong SAR	59	[UNSCEAR,2000]
Thailand	48	[UNSCEAR,2000]
Portugal	44	[UNSCEAR,2000]
OAP data	172	[UNSCEAR,2000]
Spain	39	[Quindos et al , 1994]
Canada (Saskatchewan)	19	[Kiss et al , 1988]
Rio Grande do Norte	29.2	[Malanca et al , 1996]
Mexico (Zacatecas)	23	[Mireles et al , 2003]
South India	35	[Narayanq et al , 2001]
Vietnam (South – east)	19.6	[Huy et al , 2006]

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