

Assessment of radioactivity for gamma rays in Tuwaitha Site and surrounding AreasHayder Ahmed Hasaan, Nazar A.Hussain, Dr.Mahannad Kh. Mohammed , Alaa F. Hashim , Basim T. Aereabe

Assessment of radioactivity for gamma rays in Tuwaitha Site and surrounding Areas

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Abstract

In this study, and over three years from 2008-2010 evaluation of the radioactivity of the areas around the former Tuwaitha nuclear site (which is 20 kilometers southeast of Baghdad) in addition to the villages of Ishtar and AL-Ta'mim which are located inside the Tuwaitha site, to protect the environment and residents from the potential hazard of ionization radiation.

Measurements of Gamma rays were carried out in the outdoor at high one meter from the surface of the ground using a portable radiation detectors with high sensitivity, the radiological surveys showed the outdoor dose rates range from (0.08 - 0.11) $\mu\text{Sv/hr}$, with an average of 0.9 $\mu\text{Sv/hr}$ for the regions Ishtar , AL-Ta'mim villages and inside Tuwaitha site by using Ludlum. While the dose rates outdoor range from (0.12-0.16) $\mu\text{Sv/hr}$, with an average of 0.13 $\mu\text{Sv/hr}$ for the regions surrounding Tuwaitha site by using FAG. These values are comparable with other regions in the Baghdad city, which indicates there is no significant increase in reading rates of activity.

The radiological analyses of the collected soil samples were done in the laboratory of the center of Radiological Researches / Ministry of sciences & Technology according to the international specifications and by using gamma spectrometry (which consist of High- purity Germanium Detector) with a efficiency of 40% and resolution 2 keV for at 1.33Mev gamma ray photo peak of Co-60 source,. The Laboratory results of 5 soil samples indicated there were no significant levels of radioactivity for the natural radionuclides in the series of ^{238}U and ^{232}Th , as background levels, in addition to the presence of low

Assessment of radioactivity for gamma rays in Tuwaitha Site and surrounding AreasHayder Ahmed Hasaan, Nazar A.Hussain, Dr.Mahannad Kh. Mohammed , Alaa F. Hashim , Basim T. Aereabe concentrations of an isotope ^{137}Cs . The values are comparable to those for other regions in Baghdad city ,and thus can considered normal concentrations.

1- INTRODUCTION

Natural radioactivity is a fact of life. We literally live in a sea of radioactive material, and we are daily bombarded with gamma rays and alpha and beta particles of varying intensities, Environmental radioactivity measurements are necessary for determining the background radiation level due to natural radioactivity sources of terrestrial and cosmic origin. The terrestrial component is due to the radioactive nuclides that are present in air, soils, rocks, water and building materials in amounts that vary significantly depending on the geological and geographical features of a region. The cosmic radiation originates from space as cosmic rays whose contribution to background changes mainly with elevation and latitude. In addition to these natural sources, the level of background radiation in a region is affected from man-made sources such as those from nuclear activities and accidents and there is a great interest in the study of natural environmental radiation and radioactivity in soil because the population is exposed to natural radioactivity at different levels depending on natural radioactive minerals in each region in the world naturally occurring radiation and environmental radioactivity has led to the performance of extensive surveys in many countries of the world. Such investigations can be useful for both the assessment of public dose rates and the performance of epidemiological studies, as well as to keep reference–data records, in order to ascertain possible changes in the environment radioactivity due to nuclear, industrial, and other human activities (UNSCEAR, 2000) [1].

Survey studies have been performed to assess the natural radioactivity and estimation Gamma absorbed dose rate in air , natural radioactivity arises mainly from the primordial radionuclides, such as ^{40}K , and the radionuclides from ^{238}U and ^{232}Th series and their decay products, which are present at trace levels in all ground formations [2].

This study aims to assess the environmental radioactivity level of the regions in and surrounding Tuwaitha site based on the following types of measurements; outdoor gamma dose rates in air and radionuclide activity concentrations in soil, finally comparisons of the result from this study with national and world averages are presented and the studies of this sort are expected to serve as baseline data of natural radioactivity level and will be useful in assessing public doses in these regions.

2- Tuwaitha site

The Tuwaitha Nuclear Research Centre is located at a distance of 20 kilometers south-east of Baghdad, which was included the 18 nuclear facility

Assessment of radioactivity for gamma rays in Tuwaitha Site and surrounding AreasHayder Ahmed Hasaan, Nazar A.Hussain, Dr.Mahannad Kh. Mohammed , Alaa F. Hashim , Basim T. Aereabe

were built according to the agreement signed between the Iraqi government and the former Soviet Union on July 14, 1960, The facility is surrounded by a sand berm (6.4 km) around and (50 m) high. Some 2000 Iraqi men, women and children living in a villages (Ishtar & AL-Ta'mim) near the former Tuwaitha nuclear site .

Most of the nuclear facilities in Tuwaitha site were destroyed during the second Gulf war in 1991, the present situation of these facilities are unacceptable therefore subjected to decommissioning and remediation program. since 2004 the health physics center/Hazmat Directorate formed a team in the Tuwaitha site which they have experience in the field of Radiation protection to implement an environmental radioactivity monitoring programme around the Tuwaitha nuclear site to ensure the safety of the public living in and around the site.

3- MATERIALS AND MEOTHODES

3.1 Determination of the natural background level :

The radiological survey is performed in the zaapharaniah region(which distance about 3 Km from the study area) by using the survey meters (Ludlum ,FAG) to determine the natural background level, then soil samples from this area undertaken according to the international standards related to this subject, the soil samples were analyzed in the laboratory to determine the concentration of radionuclides [3].

3.2 Survey Strategy and Criteria :

To facilitate performance of characterization and confirmatory survey, the regions inside and surrounding Tuwaitha site was divided into 208 grid boxes ; 128 grid boxes of 125 m x 125 m for Ishtar & AL-Ta'mim villages , 48 grid boxes of 500 m x 500 m for open field areas in Tuwaitha site and 32 grid boxes of 250 m x 250 m for the regions surrounding Tuwaitha site ,measurements are taken at locations near the centre of the grid box as far as possible and on 1 meter above the ground level [4].

3.3 Portable instruments:

3.3.1 LUDLUM :The exposure rates measurements were guided by using the hand-held scintillation counter type Ludlum (model 2241-2 survey meter Sweetwater Texaco, units are micro roentgens per hour($\mu\text{R/hr}$) and/or counts per minute) ,the counter consists of thallium - activated sodium iodide NaI (TI) crystal ,the instrument was calibrated using a Cs-137 standard source supplied by the manufacturer[5].

The conversion of instruments display in $\mu\text{R/hr}$ to $\mu\text{Sv/hr}$ units is depends and obtains from the following equations [3] :

$$H_T = \sum_R W_R D_{T,R} \dots\dots\dots (1)$$

Assessment of radioactivity for gamma rays in Tuwaitha Site and surrounding AreasHayder Ahmed Hasaan, Nazar A.Hussain, Dr.Mahannad Kh. Mohammed , Alaa F. Hashim , Basim T. Aereabe

H_T = equivalent dose in tissue T (Sv)

W_R = radiation weighting factor (for gamma radiation and for all energies = 1)

$D_{T,R}$ = absorbed dose (Rad) averaged over tissue T due to radiation R , and

$$E = \sum_T W_T H_T \quad \dots\dots\dots (2)$$

E = effective dose to the individual(Sv)

W_T = tissue weighting factor (for whole body = 1),

From equation 1 and 2 :

$$E \text{ (Sv)} = D \text{ (Rad)} \quad \dots\dots\dots (3)$$

since

$$1 \text{ R (Roentgen)} = 0.96 \text{ Rad in tissue}$$

Thereby , the reading of exposure (R) multiply by the factor 0.96 to convert to absorbed dose (Rad) which is equal effective dose (Sv) .

3.3.2 FAG : the type of the survey meter FAG is FH 40 F2 used for measurement gamma and x – rays , the detector is Geiger - Muller- tube , the measured value is displayed both digitally by means of a numeric readout and also in analog form by the length of a bar , determination of quantitative values in dose rate [6].

3.3.3 Global Positioning System (GPS) the device has the ability to connect to the satellite to determine the coordinates of a particular site, and can be connected with ten satellites, and is also used to determine the height above sea level, and speed control [7].

3.4 Gamma –ray spectrometry

The radiological analyses of the collected soil samples were done in the laboratory of the center of Radiological Researches in the Ministry of sciences and Technology by using Gamma spectrometry which consist of High-Purity Germanium (HPGe) detector with efficiency of (40%) and resolution 2 keV at 1.33 Mev gamma ray photo peak of ^{60}Co source , the data are collected using digital spectrum analyzer (DSA-2000) furthermore the analysis of each measured gamma ray spectrum was conducted by dedicated software program (Genie-2000,USA) ,Marinelli Beaker geometry is used for soil sample measurements ,calibration and efficiency of the system was carried out using multi–gamma ray standard source (MGS-5,Canberra) of Marinelli Beaker geometry [8].

3.5 Radiometric measurements

The collected soil samples were dried at room temperature for 7 days, the soil samples were grained by using 2 mm sieve. About (0.5-1.2) from each sample was packed in a plastic container, sealed well and stored for about 30 days before analysis. This allowed the in-growth of uranium and thorium decay products prevent the escape of radiogenic gases ^{222}Rn and ^{220}Rn and allowed

Assessment of radioactivity for gamma rays in Tuwaitha Site and surrounding Areas

Hayder Ahmed Hasaan, Nazar A.Hussain, Dr.Mahannad Kh. Mohammed , Alaa F. Hashim , Basim T. Aereabe

secular equilibrium between ^{238}U , ^{232}Th and their decay products. After attainment of secular equilibrium, each of the prepared samples was measured in the laboratory. Each sample was counted for 3600 seconds. Since uranium and thorium are not γ -emitters, they were measured indirectly through the γ -ray photons emitted from their decay products. The radioactivity concentration of ^{226}Ra was determined from γ -ray energies of its daughters ^{214}Pb (351.92 and 295.21 keV) and ^{214}Bi (609.31 keV) and the ^{232}Th was determined from γ -ray energies of its daughters ^{212}Pb (238.63 keV),and ^{228}Ac (911.07 and 969.11 keV). The radioactivity concentrations of ^{40}K and ^{137}Cs were determined from their γ -ray energy of 1460.80 keV and 662 keV respectively [9].

4- RESULTS AND DISCUSSION

4.1 Measuring dose rates for Gamma radiation outdoor

The results of coordinates and dose rates in natural background levels at zaapharaniah region by using Ludlum , FAG are listed below :

GPS		Dose Rate $\mu\text{Sv/hr}$	
X	Y	Ludlum	FAG
3324085	4450594	0.08	0.12

The results of radiological surveys of the Ishtar & AL-Ta'mim villages using the hand-held radiation monitor **Ludlum** to measure dose rates for gamma radiation outdoor , are shown in Tables (1,2).

Table (1) dose rates of gamma radiation outdoor for Ishtar village

Grid No.	Dose Rate $\mu\text{Sv/hr}$	Grid No.	Dose Rate $\mu\text{Sv/hr}$	Grid No.	Dose Rate $\mu\text{Sv/hr}$	Grid No.	Dose Rate $\mu\text{Sv/hr}$
1	0.10	17	0.10	33	0.09	49	0.10
2	0.09	18	0.09	34	0.11	50	0.09
3	0.08	19	0.11	35	0.08	51	0.11
4	0.10	20	0.08	36	0.09	52	0.09
5	0.09	21	0.08	37	0.10	53	0.09
6	0.11	22	0.11	38	0.11	54	0.08
7	0.09	23	0.09	39	0.08	55	0.10
8	0.08	24	0.08	40	0.09	56	0.09
9	0.10	25	0.11	41	0.08	57	0.11
10	0.08	26	0.09	42	0.09	58	0.10
11	0.11	27	0.09	43	0.08	59	0.09
12	0.09	28	0.10	44	0.10	60	0.08
13	0.10	29	0.11	45	0.09	61	0.10
14	0.09	30	0.09	46	0.08	62	0.08
15	0.11	31	0.08	47	0.11	63	0.11
16	0.10	32	0.10	48	0.09	64	0.09

Assessment of radioactivity for gamma rays in Tuwaitha Site and surrounding AreasHayder Ahmed Hasaan, Nazar A.Hussain, Dr.Mahannad Kh. Mohammed , Alaa F. Hashim , Basim T. Aereabe

Table (2) dose rates of gamma radiation outdoor for AL-Ta'mim village

Grid No.	Dose Rate $\mu\text{Sv/hr}$	Grid No.	Dose Rate $\mu\text{Sv/hr}$	Grid No.	Dose Rate $\mu\text{Sv/hr}$	Grid No.	Dose Rate $\mu\text{Sv/hr}$
1	0.09	17	0.11	33	0.09	49	0.08
2	0.11	18	0.09	34	0.11	50	0.09
3	0.09	19	0.08	35	0.09	51	0.09
4	0.10	20	0.11	36	0.08	52	0.11
5	0.10	21	0.10	37	0.10	53	0.09
6	0.08	22	0.09	38	0.08	54	0.08
7	0.10	23	0.11	39	0.11	55	0.10
8	0.11	24	0.09	40	0.09	56	0.08
9	0.10	25	0.08	41	0.10	57	0.10
10	0.09	26	0.10	42	0.09	58	0.09
11	0.11	27	0.08	43	0.08	59	0.10
12	0.10	28	0.10	44	0.10	60	0.09
13	0.10	29	0.09	45	0.08	61	0.08
14	0.09	30	0.10	46	0.10	62	0.08
15	0.11	31	0.09	47	0.09	63	0.09
16	0.08	32	0.08	48	0.11	64	0.10

Because the location of the measuring points in the Ishtar, AL-Ta'mim villages can be identified easily and the grid boxes were convergent, so there is no need to use GPS.

Furthermore, the radiological survey was conducted using hand-held radiation monitors ; Ludlum in the regions in Tuwaitha site, and FAG in the regions surrounding Tuwaitha site (Riyadh, Jisr Diyala ,AL- Waradia - because many of orphan sources has been found in these regions after 2004) to measure dose rates for gamma radiation outdoor, also determined coordinates of measurement points using the GPS coordinates , the results are shown in Tables (3,4).

Assessment of radioactivity for gamma rays in Tuwaitha Site and surrounding AreasHayder Ahmed Hasaan, Nazar A.Hussain, Dr.Mahannad Kh. Mohammed , Alaa F. Hashim , Basim T. Aereabe

Table (3)dose rates for gamma radiation outdoor for regions in Tuwaitha site

Grid No.	GPS		Dose Rate $\mu\text{Sv/hr}$	Grid No.	GPS		Dose Rate $\mu\text{Sv/hr}$
	X	Y			X	Y	
1	3321922	4452579	0.09	25	3319111	4454301	0.11
2	3321705	4452687	0.10	26	3319069	4454257	0.08
3	3321400	4452813	0.08	27	3319007	4454107	0.08
4	3321309	4452927	0.11	28	3318903	4454001	0.09
5	3320217	4452999	0.10	29	3318881	4454098	0.08
6	3321016	4452001	0.09	30	3318789	4454183	0.09
7	3320989	4453112	0.08	31	3318701	4454310	0.08
8	3320796	4453201	0.09	32	3318666	4454389	0.11
9	3320698	4453287	0.10	33	3318599	4454417	0.10
10	3320500	4453329	0.08	34	3318511	4454502	0.10
11	3320408	4453512	0.09	35	3318601	4454598	0.11
12	3320311	4453609	0.08	36	3318703	4454633	0.08
13	3320199	4453720	0.09	37	3318793	4454700	0.09
14	3320101	4453801	0.10	38	3318844	4454756	0.11
15	3320003	4453888	0.09	39	3318897	4454811	0.08
16	3319902	4454008	0.08	40	3318984	4454890	0.08
17	3319813	4454117	0.11	41	3318998	4454910	0.10
18	3319777	4454200	0.10	42	3319278	4450281	0.11
19	3319700	4454299	0.09	43	3318846	4451209	0.09
20	3319656	4454375	0.10	44	3318616	4452262	0.10
21	3319518	4454411	0.11	45	3318703	4452180	0.09
22	3319467	4454501	0.09	46	3318800	4452138	0.10
23	3319301	4454478	0.08	47	3318894	4452103	0.09
24	3319209	4454400	0.08	48	3318963	4452062	0.08

Assessment of radioactivity for gamma rays in Tuwaitha Site and surrounding AreasHayder Ahmed Hasaan, Nazar A.Hussain, Dr.Mahannad Kh. Mohammed , Alaa F. Hashim , Basim T. Aereabe

Table (4) dose rates for gamma radiation outdoor for regions surrounding Tuwaitha site

Grid No.	GPS		Dose Rate $\mu\text{Sv/hr}$	Grid No.	GPS		Dose Rate $\mu\text{Sv/hr}$
	X	Y			X	Y	
1	3322046	4452396	0.12	17	3313088	4449989	0.15
2	3322100	4452313	0.13	18	3313987	4449832	0.14
3	3322153	4452221	0.12	19	3312935	4450732	0.13
4	3322250	4452103	0.14	20	3312888	4450789	0.13
5	3322301	4452168	0.13	21	3312765	4450840	0.16
6	3322334	4452087	0.12	22	3312601	4450893	0.12
7	3322768	4452026	0.14	23	3312510	4450921	0.13
8	3322989	4451701	0.15	24	3312391	4432619	0.12
9	3322897	4451763	0.14	25	3311303	4432666	0.14
10	3322601	4451856	0.16	26	3311247	4432701	0.13
11	3322554	4451900	0.13	27	3311201	4432796	0.12
12	3322813	4452717	0.14	28	3311145	4432821	0.14
13	3322743	4452779	0.13	29	3311066	4432881	0.15
14	3313333	4449821	0.12	30	3310980	4432969	0.16
15	3313221	4449900	0.16	31	3310900	4433035	0.14
16	3313198	4449934	0.12	32	3310881	4433127	0.13

The results of average values of dose rate in the study regions for gamma radiation outdoor by using the handheld radiation survey instruments during period of the study were falls within the natural background levels, As has been observed in a number of national and international research that have been published about the radiation exposure resulting from gamma radiation [1,10] .

4.2 Concentration of Radionuclides in the soil samples :

Since there was no increase in radioactivity readings for areas that have been measured by using portable radiation detectors (Ludlum , FAG) and The concentration of radioactive elements in the soil is of an important place in any country to establish a base of background information on the levels of natural background level and environmental map of the area, therefore we selected 2 soil samples from Ishtar & AL-Ta'mim villages, and 2 soil samples from regions in & surrounding Tuwaitha site, the results are shown in Table(5).

Table (5) Specific activities of radionuclides in soil samples at different locations

Sample code	Specific activity of radionuclides (Bq/kg)					
	Bi-214	Pb-214	Ac-228	Pb-212	K-40	Cs-137
B.G	9.73±0.57	9.47±0.63	8.24±0.54	4.8 ±0.36	342.8±15.3	2.1±0.31
ISH	12.5±0.92	12.12±1.16	12.5±0.84	10.2±0.68	357.7±16.4	1.4±0.28
TAM	9.97±1.02	11.05±0.75	8.17±0.90	5.9 ±0.3	418.4±17.6	7.1±0.55
INTU	12.58±0.9	12.12±1.16	12.5±0.84	10.28±0.68	280.7±12.9	4.6±0.41
SUR	8.62±0.48	8.65±0.40	5.82±0.36	8.69±0.47	297.6±12.2	3.8±0.34

Where

B.G : soil sample from zaapharaniah region

ISH : soil samples from ISHTAR village

TAM : soil samples from AL-Ta'mim village

INTU : soil samples from Tuwatha site

SUR : soil sample from surrounding Tuwatha site

The values of Specific activities of radionuclides in soil samples are also comparable to those for neighboring regions in Baghdad city which indicates there is no significant increase in the levels of radioactivity .

5- CONCLUSION AND RECOMMENDATION :

5.1 CONCLUSION :

1- This study intends to layout the background radiation level in Tuwaitha site and surrounding region through field investigations and lab tests, the results obtained indicate that the study area has a background radiation level and within the natural limits .

2- After 25 years, there is still The manmade fission product residue ¹³⁷Cs in the soil samples which would come down to this part of the earth from the atmosphere following the nuclear power plant accident at Chernobyl on 26 April 1986 and other previous test of nuclear devices around the world .

Assessment of radioactivity for gamma rays in Tuwaitha Site and surrounding AreasHayder Ahmed Hasaan, Nazar A.Hussain, Dr.Mahannad Kh. Mohammed , Alaa F. Hashim , Basim T. Aereabe

3- Although there is a slight variation in the reading of portable radiation detectors (resulting from the differences in specifications of detectors) but remain within the natural background radiation as confirmed by national and international studies.

5.2 RECOMMENDATION :

It is important to monitor the area in and around Tuwaitha site by using thermoluminescence dosimeters (TLDs) in order to ensure that their continuous nuclear decommissioning project, treatment and disposal of radioactive waste does not lead to an unwarranted increase in the radiation level .

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تقييم النشاط الإشعاعي لأشعة كاما في موقع التويثة والمناطق المحيطة به

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الخلاصة

تم في هذه الدراسة وعلى مدى ثلاثة أعوام 2008 - 2010 تقييم النشاط الإشعاعي لأشعة كاما للمناطق حول موقع التويثة النووي (الذي يبعد 20 كم جنوب شرق العاصمة بغداد) إضافة إلى قريتي عشتار والتأميم اللتان تقعان داخل موقع التويثة ، لحماية البيئة والسكان من الآثار الضارة المحتملة للأشعة المؤينة.

أجريت قياسات أشعة كاما في الهواء الطلق وعلى ارتفاع متر واحد من سطح الأرض باستخدام أجهزة الكشف الإشعاعي المحمولة ذات الحساسية العالية تراوحت معدلات الجرعة الإشعاعية (0.08-0.11) مايكرو سيفرت/ساعة وبمتوسط 0.9 مايكرو سيفرت/ساعة لمناطق قريتي عشتار و التأميم وداخل موقع التويثة باستخدام جهاز Ludlum ، أما قراءات معدلات الجرعة الإشعاعية لمناطق خارج موقع التويثة فتراوحت (0.12-0.16) مايكرو سيفرت/ساعة وبمتوسط 0.13 مايكرو سيفرت/ساعة باستخدام جهاز FAG، قورنت هذه القيم مع معدلات الجرعة الإشعاعية لأشعة كاما لمناطق أخرى في مدينة بغداد والتي أظهرت عدم وجود زيادة محسوسة في النشاط الإشعاعي للمناطق التي تم قياسها .

لقد تم جمع ، تحضير وتحليل نماذج التربة في مركز البحوث الإشعاعية - وزارة العلوم والتكنولوجيا ووفق المعايير والمواصفات المعتمدة عالميا . استخدمت منظومة تحليل أطياف كاما والتي تتألف من كاشف الجرمانيوم عالي النقاوة ذو كفاءة 40 % وقدرة فصل 2 keV للطاقة

Assessment of radioactivity for gamma rays in Tuwaitha Site and surrounding AreasHayder Ahmed Hasaan, Nazar A.Hussain, Dr.Mahannad Kh. Mohammed , Alaa F. Hashim , Basim T. Aereabe

1.33 MeV للقيمة الضوئية لمصدر Co-60 ، أشارت النتائج المختبرية لـ 5 نماذج تربة الى عدم وجود زيادة محسوسة في النشاط الإشعاعي للنويدات المشعة الطبيعية في سلسلتي اليورانيوم-238 والثوريوم-232 إضافة إلى وجود تراكيز منخفضة لنظير Cs-137 وبمقارنة هذه النتائج مع مناطق أخرى في مدينة بغداد يمكن اعتبارها طبيعية .