Exposure rates and radiation doses due to ambient gamma rays/Anbar governorate.

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ARTICLE INFO

Received: 19 / 5 /2022
Accepted: 28 / 5 /2022
Available online: 14/6/2012
DOI:10.37652/juaps.2009.37789

Keywords:
Exposure rates ,
radiation ,
ambient ,
gamma rays,
Anbar.

ABSTRACT

Radiation exposure rates and radiation doses were measured in 174 locations in the Western Desert. Exposure rates were measured 1m above the ground with NaI (Tl) scintillation detector. Total radiation doses due to external exposure to the ambient gamma ray in the same previous locations were measured with FAG-FH 40 F2. The radioactivity concentrations of 238U, 232Th and 40K in selected soil and rocks samples were measured using gamma spectroscopy system based on high purity Germanium detector. Then, absorbed doses due to presence of 238U, 232Th and 40K in the samples were estimated. The exposure rates ranged between (5.0-71.7) μR/h, while the average of radiation dose due to the exposure to ambient gamma ray ranged between (0.7-3.32) mSv/y. Doses due to expose to the concentrations of 238U, 232Th and 40K in the soil and rocks of the Western Desert were calculated. The average of these exposure doses ranged between (0.03-1.84)mSv/y.

Introduction:

Humans are exposed to many sources of radiation in environment of which natural sources are the most important ones. The natural sources of radiation are primordial, cosmic rays and cosmogenic radionuclides (1). The primordial radionuclides are the most important contributors to public exposure (2). Many studies were achieved to measure the exposure rates and radiation doses in many countries such as Korea (3), Taiwan (4), Switzerland (5), and Vietnam (6). All these countries have normal radiological background according to criterion set by UNSCEAR (7).Few researchers studied the exposure rate and doses due to natural radioactivity in Iraq (8-9). Some another researchers studied the exposure rate and radiation doses due to the environmental radioactivity (10-11). These studies restricted in or near the cities.

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The study area represents the western part of Iraq, which is called the Western Desert. The geological formations and units that outcrop in the area are of ages ranging from early Permian to recent and consist mostly of carbonate and clastic rocks covered by 0.5 m -3 m of quaternary units (12-15). Table –1 shows the geological formations that expose in the study area and, Fig -1 shows the geological map of the area (16).

Fieldwork and methodology:

Radiation exposure rates and radiation doses were measured in 174 locations in the Western Desert- Iraq (Fig - 2).

Exposure rates were measured 1m above the ground with NaI (Tl) scintillation detector (BGS-4, Scintrex scintillation counter, Canada). A total of 50 readings were taken for each environmental location, and then the average was calculated to represent the average exposure rate in that location. These readings were converted to exposure rates in μR/h by using equation published earlier (16).

Total radiation doses due to external exposure to the ambient gamma ray in the same previous locations were measured with FAG-FH 40 F2- Germany. 25 readings in μSv/h were taken in every location, and then their average was calculated to represent the ambient exposure dose in that location.

Soil and rocks samples were selected from geologic units and formations outcropping in the measuring locations in the study area in order to measure the radioactivity concentrations of 238U, 232Th and 40K. Gamma spectroscopy system based on high purity Germanium detector (tennelec, USA) of efficiency 40% was used in the measuring. Absorbed doses (in nGray/h) due to presence of 238U, 232Th and 40K in the samples were estimated using the equation published before:

D (nGy.h-1) = 41.7 x A(K-40) + 462 x A(U-238) + 604 x A(Th-232) (17)

Where D is dose rate in nanogray/h and A (40K), A (238U), A (232Th) are the activity concentrations of (40K), (238U) and (232Th) in Bq/kg. The absorbed doses rates were converted to effective doses to standing body by using converting factor of 0.7 (17).

Global positioning system (GPS) from e -Trex, German was used to determine the coordinates of measuring locations.

Results and discussion:

Table-2 shows the exposure rates and the radiation doses due to expose to ambient gamma rays in measuring locations. And table- 3 represents the activity concentrations of 238U, 232Th and 40K in the selected soil and rocks samples of the formations in the study area.

The exposure rates ranged between (5.0-71.7) μR/h, while the average of radiation dose due to the exposure to ambient gamma ray ranged between (0.7-3.32) mSv/y. Contour map was drawn to represent these values in the area.

Fig. (1) represents the exposure rates measured in the area. We divided the area into four different regions.

The first one that has exposure rates range between (5-9) μR/h. These values within the exposure rates from the radiation background for most regions of Iraq (7). These values represent the locations which formations of Najma, Nahr-Umr-Mauddud, Rutba-Msaad and Nafayl beds and quaternary deposits are exposing.

The second region is the locations that have exposure rates range between (9-16) μR/h. these values are predominate in the Western Desert and include most of the geological formations that outcrop in the study area. These values mostly similar to that of the northern part of Iraq which be affected with Chernobyl nuclear plant accident in 1986(7), and slightly higher than the first region, this could be due to increasing of the nature radionuclides contain in the rocks and soil of this region as well as due to the influence of the regional fallouts.

The third region with exposure rates values range between (16-25) μR/h. these values are high in comparison with the rest areas of Iraq. This region includes the locations in middle and west of the study area with formations of Zor horan, Hussainyat, Amij, Jeed, Akashat and Ratga, and some locations near the cities of Al-Qaim, Haditha-Anah and Hit-Al-Baghdadi where the upper member of Euphrates formation is exposing.

The increasing of the exposure rates in these locations is due to the high concentrations of the natural radionuclides in the rocks formed the formations that expose in these locations.

The forth region includes the locations with exposure rates more than 25 μR/h. These locations are with limited expand, include kaoline clay mine in Gaara formation, bauxite ore deposits within Ubaid formation, clastic rocks in Hussainyat formation and Amij formation and phosphate rocks in Akashat formation west of the study area and also includes the depression fill deposits and Sebkha deposits within quaternary deposits near city of Hit east of the study area.

The increasing of the exposure rates in these locations is due to the increasing in concentrations of the radionuclides (U, Th, and K).in the rocks that expose in these locations. The range of the concentrations of these radionuclides were (127-610) Bq/kg of 238U, (18-125) Bq/kg of 232Th and (15-406) Bq/kg of 40K.

Generally the radiation doses in the study area ranged between (0.7-3.33) mSv/y. Some locations were with relatively high doses, include locations of Gaara and Akashat in the west of the area where clastic rocks (sandstone and claystone) that belong to Gaara, Ubaid, Hussainyat and Amij formations are exposing. These rocks contain relatively high concentrations of Uranium and Thorium radionuclides (range between (127-359) Bq/kg of 238U and (68-125) Bq/kg of 232Th). Also phosphate rocks are outcropping in these locations, which belong to Jeed, Ratga and Akashat formations. These rocks contain relatively high concentrations of Uranium that associated with the phosphate minerals (range between (96-610) Bq/kg).

Other locations with relatively high radiation doses are in north and northeast of the study area such as Wadi Sehela north city of Hit and village of Jerjeeb east of city of Al-Qaim. In these locations, limestone rocks belong to upper member of Euphrates formation are exposing, which contain relatively high concentration of 238U, about (157) Bq/kg. Depression fill deposits and Sebkha deposits are also outcropping in these locations with relatively high concentrations of Uranium and Thorium radionuclides or their daughters.

The average of the radiation doses at most of the locations in the Western Desert was (0.9) mSv/y. this value is higher than equivalent doses due to the normal background radiation in USA (19) and Bikini atoll (20) and also higher than most of the locations in Iraq such as in Babylon governorate, which range between (0.47-0.55) mSv/y (21).

In this study, doses due to expose to the concentrations of 238U, 232Th and 40K in the soil and rocks of the Western Desert were calculated. (17) The average of the exposure doses ranged between (0.03-1.84) x 10-3 Sv/y. Fig- 4 represent distribution of the calculated effective doses rates due to the expose to the concentrations of 238U, 232Th and 40K in the soil and rocks of the study area. These values are near to the equivalent doses in many of areas with high background radiation in the world (19, 22). But these values consider being high in comparison with that published by UNSCEAR (23) which estimated the total annual effective doses to adult from the natural source about 2.4 mSv/y and 0.46 mSv/y result from ground gamma rays not included radon and his daughters. You can note that these estimations usually to the areas that have normal background radioactivity.

The doses due to presence of 238U, 232Th and 40K in some locations were relatively high in comparison with the doses that result by the crust's rocks with typical contains of 238U, 232Th and 40K which range between (0.16-0.4) x 10-3 Sv/y in sedimentary rock and about (0.9) x 10-3 Sv/y in igneous rocks(2).

Maximum effective dose was (1.84) mSv/y above the phosphate rock in Akashat phosphate mine. And the effective doses in mines of Hussainyat and Bauxite clays were higher than (1) mSv/y and we can note that total ambient exposure doses, which were measured in the same locations, were ranged between (1.23-3.07) mSv/y. These values are relatively high, but much lower than (50) mSv/y permissible threshold of IAEA to the workers. (24)

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P- ISSN 1991-8941 E-ISSN 2706-6703 *Journal of University of Anbar for Pure Science (JUAPS)* Open Access
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Table – 1 geological formations that expose in the study area. (The symbols in this table represent the symbols in the geological map in Fig -1) (Geological map of Iraq,Geosurv.1986).

Period	**Symbol**	**Formation**	**Period**	**Symbol**	**Formation**
Jurassic	**J5**	**Najmah**	**Pliocene**	**Z**	**Zahra**

Permian			Triassic						
P			T1	T2		J1	J2	J3	J4
Gaara			Zor Horan	Mullussa		Ubaid	Hussainyat	Amij	Muhaiwir
Cretaceous			Paleocene	Eocene		Oligo -cene		Miocene	
C1	C2	C3/C4	Pa1/Pa2	E1/D1	E2	O1	O2	M1/M2	M3
Nahr Umr-Mauddud	Rutba-Msaad	Jeed/Hartha -Tayarat	Akashat/Umm Er Radhuma	Ratga/Damma m	Jaddala	Shekh Alas& Shurau	Anah	Uphrates/G har	Fatha

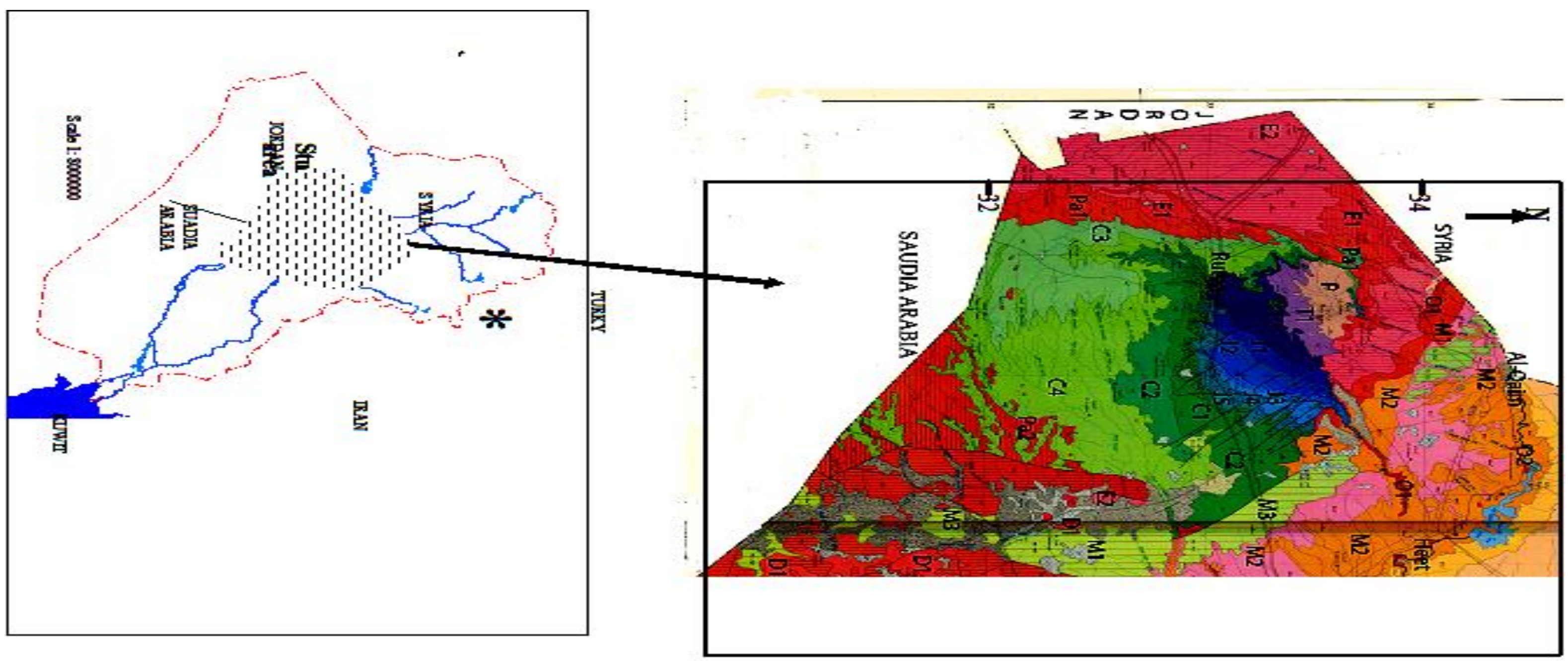

Fig.-1 The geological map of the study area

P- ISSN 1991-8941 E-ISSN 2706-6703 *Journal of University of Anbar for Pure Science (JUAPS)* Open Access
2009,(3), (3) :90-100

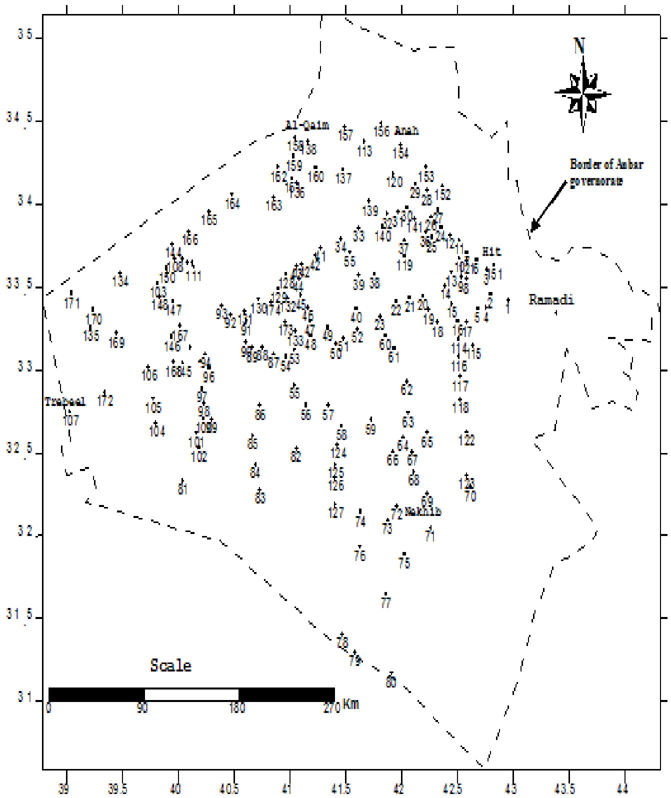

Fig- 2 The measuring locations in the study area.

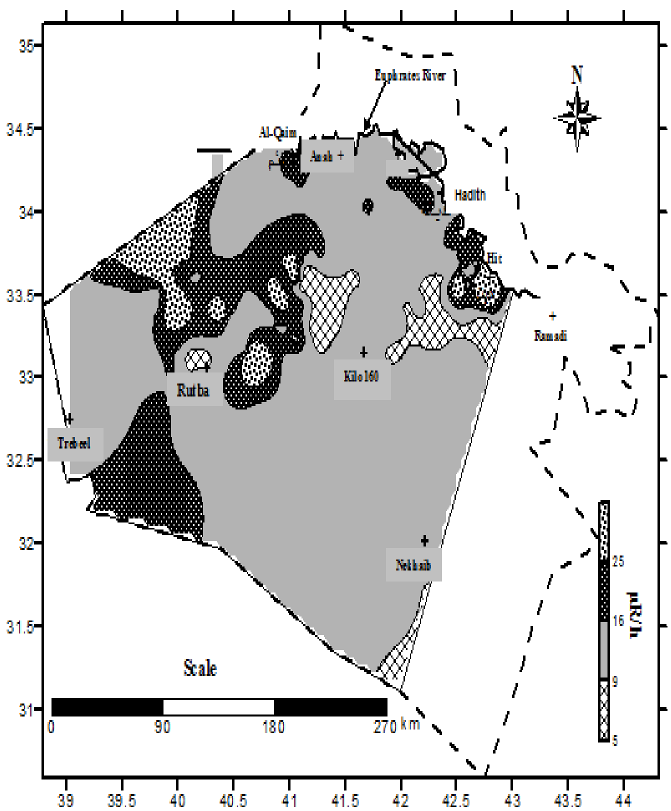

Fig – 3 Radiation exposure regions map in the study area.

Table – 2 Range and average of exposure rates and the radiation doses due to expose to ambient gamma rays at the measuring locations in the study area.

No.	Geological Formation	Location No.	Range of Exposure rate (cps) (Average)	Range of Exposure rate (µR/h) (Average)	Range of Dose (μSvh^{-1}) (Average)	Range of Dose ($mSvy^{-1}$) (Average)
1	Surface Soil	151 – 174	83 - 232 (127)	10 – 28 (15)	0.1 – 0.25 (0.14)	0.88 – 1.84 (1.24)
2	Valley deposits	4,5,11,12,48,70 ,71,85,10, 13	58 – 150 (91)	7 – 16 (11)	0.1 – 0.19 (0.12)	0.79 –1.66 (1.05)
3	Depression fill deposits	28,40,41,68,72,	89 – 163 (129)	11-20 (14.6)	0.12 – 0.17 (0.14)	١.٠٥ - ١.٤٩ (١.٢٤)
4	Sebkha	2, 3,9	297 – 592 (459)	36 –72 (55.6)	0.25 - .0.38 (0.32)	2.19 – 3.33 (2.77)
5	Slope deposits	24, 29	118 – 163 (140)	14 – 20(17)	0.15 – 0.17 (0.16)	1.31 – 1.49 (1.4)
6	Habbaria gravels+ surface soil	62, 63, 65, 77	74 – 108 (89)	9 – 13 (10.8)	0.12 – 0.15 (0.14)	1.05 – 1.31 (1.18)
7	Calcrete sediments	42	87	11	0.12	1.05
8	Gypcrete	1, 6, 8, 14	59 – 86 (71.5)	7 – 10 (8.5)	0.09 – 0.14 (0.11)	0.79 – 1.23 (0.95)

16	15	14	13	12	11	10	9
Jadala formation	Ratga Formation	Shurau and Sheikh Alas Formation	Anah formation	Euphrates formation	Ghar formation	Nfayil beds	Zahra formation
107, 134, 135	45, 106, 109, 148	140, 141	113	7, 25, 26, 27, 33, 34, 55, 136, 137, 138, 139, 35, 32, 36, 20, 37, 17, 19, 18, 30, 31, 38, 39, 114, 115, 116, 117, 119, 120	44, 142, 122	118, 121	21, 22, 123
125 – 145 (133)	74 – 160 (125)	80 – 88 (84)	٧٠	60 – 250 (95.5)	52 –93 (71)	76 – 80 (78)	74 – 85 (78)
15 – 18 (16,3)	9 – 19 (15)	10 – 11 (10.5)	8	7 – 30 (11.5)	6 – 11 (8.3)	9 – 10 (9.5)	9 – 10 (9.3)
0.15 – 0.2 (0.166)	0.09 – 0.21 (0.15)	0.1	0.1	0.1 – 0.3 (0.13)	0.08 – 0.13 (0.1)	0.09 – 0.11 (0.1)	0.12 – 14 (0.13)
1.31 – 1.75 (1.46)	0.79 – 1.84 (1.29)	0.88	0.88	0.88 – 2.63 (1.17)	0.7 – 1.14 (0.88)	0.79 – 0.96 (0.88)	1.05 – 1.23 (1.14)

25	24	23	22	21	20	19	18	17
Mauddud – Nahr Umr Formation	Rutba- Msaad formation	Mahliban Formation	Hartha Formation	Tayarat Formation	Jeed Formation	Akashat formation	Umm Er Radhuma Formation	Dammam formation
50, 51, 52	94, 96, 97, 143	23, 60, 61	56, 57, 86, 98	58, 59, 74, 78, 79, 82, 83, 84, 95, 124,125, 126,127	81, 99, 100, 101, 102, 103, 104, 108, 145, 110, 111	105, 147, 149, 150	64, 66, 73, 75, 76, 80	67, 69
82 – 90 (86.5)	41 – 116 (88)	66 – 138 (73)	82 – 95 (92)	74 – 124 (91)	88 – 190 (120)	155 – 340 (274)	66 – 99 (80.3)	91 – 108 (99.5)
10 – 11 (10.5)	5 – 14 (10.7)	8 – 17 (9)	10 – 11 (11)	9 – 13 (10. 9)	11 – 23 (14.7)	19 – 46 (33)	8 – 12 (9.7)	11 – 13 (12)
0.1 – 0.12 (0.11)	0.08 – 0.17 (0.14)	0.11 – 16 (0.12)	0.12 – 0.18 (0.14)	0.1 – 0.19 (0.125)	0.1 – 0.2 (0.14)	0.17 – 0.31 (0.26)	0.1 – 0.15 (0.118)	0.12 – 0.13 (.125)
0.88 – 1.05 (0.97)	0.7 – 1.49 (1.2)	0.96 – 1.4 (1.0)	1.05 – 1.58 (1.2)	0.88 – 1.66 (1.1)	0.88 – 1.75 (1.23)	1.49 – 2.72 (2.26)	0.88 – 1.31 (1.04)	1.05 – 1.14 (1.1)

26	Najmah Formation	46, 47, 49	67 – 90 (68)	8 – 11 (8)	0.09 – 0.14 (0.12)	0.79 – 1.23 (1.06)
27	Muhaiwir Formation	53	102	12	0.17	1.49
28	Amij Formation	54, 87, 133	90 – 253 (236)	11 – 31 (28.5)	0.17 – 0.29 (0.27)	1.49 – 2.54 (2.4)
29	Hussainyat Formation	88, 89, 132	221 – 422 (322)	31 – 51 (39)	0.23 – 0.35 (0.29)	2.01 – 3.07 (2.54)
30	Ubaid Formation	43, 128, 129	99 – 384 (237)	12 – 46 (28.5)	0.14 – 0.34 (0.24)	1.23 – 2.98 (2.1)
31	Zor Horan Formation	91, 130	90 (90)	11 (11)	0.12 - 0.13 (0.12)	1.05 – 1.14 (1.01)
32	Mullussa Formation	92, 131	91 (91)	11 (11)	0.12 - 0.13 (0.12)	1.05 – 1.14 (1.01)
33	Gaara Formation	93, 112	190 – 271 (231)	23 – 33 (28)	0.19 – 0.3 (0.25)	1.66 – 2.63 (2.15)

Locations No. in this table represent the measuring locations No. in the figure – 2

Table- 3 The activity concentrations of ^{238}U, ^{232}Th and ^{40}K in the selected soil and rocks samples of the formations in the study area and the radiation doses due to expose to the concentrations of these radionuclides.

No. of loction	Geological Formation	Radioactivity concentration (Bq/kg)			Absorbed dose (nGy/h)	Equivalent dose Sv x (10^{-3}/y)
		Th-232	U-238	K-40		
1	Gaara (residual soil)	31	96	93	67	0.41
2	Gaara (clastic rocks)	87	127	149	131	0.8
3	Mullussa	22	29	239	37	0.22
4	Zor Horan (depth)	23	130	800	107	0.66
5	Zor Horan (surface)	21	51	405	53	0.33
6	Ubaid (bauxite karsts)	125	193	15	165	1.01
7	Ubaid (surface)	13	11	219	22	0.14
8	Hussainyat (depth)	99	359	42	227	1.39
9	Hussainyat (surface)	0.5	0.5	259	11	0.07
10	Amij (depth)	68	165	216	126	0.77

20	19	18	17	16	15	14	13	12	11
Akashat (phosphate rocks)	Akashat (surface soil)	Tayarat-Hartha	Jeed	Rutba-Msaad	Mahliban (Rutba-Msaad)	Mauddud – Nahr Umr	Najma	Muhaiwir	Amij (surface)
18	33	25	٢١	11	27	24	6	20	6
610	51	43	96	8	38	21	0.5	27	21
28	149	337	٢٧١	25	354	275	260	126	45
299	50	49	٦٨	11	49	36	15	30	15
1.84	0.30	0.30	٠.٤٢	0.07	0.30	0.22	0.09	0.18	0.09

29	28	27	26	25	24	23	22	21
Euphrates (lower member)	Ghar formation	Shurau and Sheikh Alas	Anah	Dammam	Ratga (phosphate rocks)	Ratga (weathered & carbonate rocks)	Jaddala	Umm Er Radhuma
3	3	0.5	0.5	24	١٧	19	23	34
14	17	0.5	0.5	35	٣٩	415	100	38
267	20	114	174	326	١٧٤	30	450	٢٧٠
19	11	5	8	44	٣٦	204	79	٤٩
0.12	0.06	0.03	0.05	0.27	٠.٢٢	1.25	0.48	٠.٣٠

30	**Euphrates (upper member)**	**67**	**157**	**304**	**126**	**0.77**
31	**Fateha**	**11**	**0.5**	**282**	**19**	**0.11**
32	**Zahra**	**18**	**18**	**247**	**29**	**0.18**
33	**Habbaria gravels**	**30**	**13**	**449**	**43**	**0.26**
34	**Calcrete sediments**	**17**	**0.5**	**290**	**23**	**0.14**
35	**Gypcrete**	**5**	**0.5**	**288**	**15**	**0.09**
36	**Slope deposits**	**24**	**69**	**426**	**64**	**0.39**
37	**Depression fill deposits**	**19**	**66**	**345**	**56**	**0.35**
38	**Sebkha**	**25**	**8**	**406**	**36**	**0.22**
39	**Valley deposits**	**21**	**28**	**326**	**39**	**0.24**

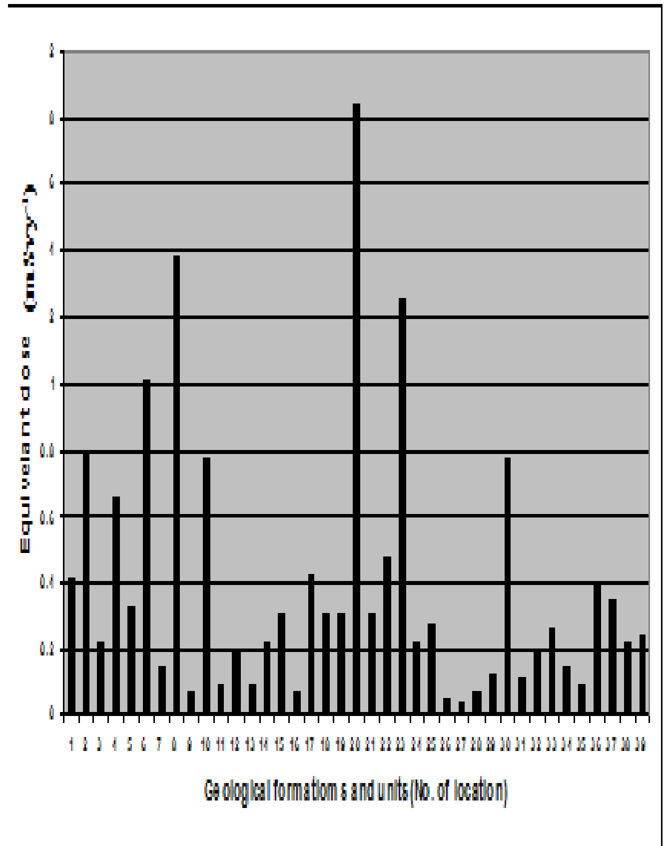

Fig -4 Distributions of the calculated effective doses rates due to the expose to the concentrations of ^{238}U, ^{232}Th and ^{40}K in the soil and rocks of the study area. (No. of location in this figure represents the No. of location in table – 3.

P- ISSN 1991-8941 E-ISSN 2706-6703 *Journal of University of Anbar for Pure Science (JUAPS)* Open Access
2009,(3), (3) :90-100

معدلات التعرض والجرع الاشعاعية الناجمة عن اشعة كاما المحيطية/محافظة الانبار

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الخلاصة:

جرى قياس معدلات التعرض الاشعاعي والجرع الاشعاعية الناجمة عن التعرض لاشعة كاما المحيطية في (١٧٤) موقعا ضمن الصحراء الغربية– العراق. قيست معدلات التعرض باستخدام العداد الوميضي المرتبط بكاشف ايوديد الصوديوم المنشط بالثاليوم بينما قيست معدلات الجرع الاشعاعية في نفس المواقع باستخدام جهاز قياس معدلات الجرع الناجمة عن التعرض الخارجي لاشعة كاما نوع فاك(FAG) الالماني المنشأ. كما تم قياس التراكيز النشاط الاشعاعي في نماذج منتخبة من الترب والصخور المتكشفة في مواقع قياس اعلاه باستخدام منظومة تحليل اطياف كاما المستندة الى عداد الجرمانيوم عالي النقاوة. تراوحت معدلات التعرض في مواقع القياس بين (٥.٠–٧١.٧) مايكرورونكن في الساعة بينما تراوحت معدلات الجرع الاشعاعية بين (٠.٧–٣.٣٢) ملي سيفرت في السنة. كما جرى احتساب الجرع الاشعاعية الناجمة عن التعرض لاشعة كاما الناتجة عن تراكيز اليورانيوم والثوريوم والبوتاسيوم مجتمعة المقاسة في نماذج الترب والصخور المنتخبة من منطقة الدراسة وتراوحت الجرع بين(٠.٠٣–١.٨٤) ملي سيفرت في السنة.