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Comparing of the uranium concentration in tap water samples at Al-Manathera and Al-Herra Regions of Al-Najaf, Iraq

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Abstract

In this work, uranium concentrations and annual effective dose in tap water samples for Al-Manathera and Al-Herra Regions of Al-Najaf, Iraq were determined using a solid-state nuclear track detector (CR-39 detector). Furthermore, we determined the uranium isotopes (^{238}U, ^{235}U and ^{234}U) for all tap water samples under study. The tap water samples are collected nearly from all regions of Al-Manathera and Al-Herra for 22 regions. Thus, the total studied samples are 40. The results indicate that, the average values of uranium concentrations and the annual effective dose in Al-Manathera were larger than the average value at Al-Herra Regions. We concluded that the average value of the uranium concentrations and total average of the annual effective dose in tap waters samples under study were lower than the recommended value of ICRP (1.9 μg/l) and 1 mSv respectively. Therefore, most of the samples could be used without any healthy risk depending on the level of natural uranium concentrations.

Keywords: Uranium concentrations; Uranium isotopes; CR-39; Tap water; Al-Najaf

1. Introduction

Human beings are subjected to radioactivity when ingesting and inhaling radionuclides tagged with food, water and air. Uranium is one of the radioactive elements that occur naturally; it is widely available in the crust of earth [1] in three well known isotopes, namely. ^{238}U, ^{235}U and ^{234}U. ^{238}U and ^{235}U are the parent nuclides of two decay series, whereas ^{234}U is resulting from a decay of ^{238}U. Uranium exists in detectable concentrations in most natural waters either in dissolved or particulate form [2]. In hexavalent form, uranium is water-soluble, and in tetravalent form relatively insoluble [3]. Uranium natural sources include the minerals pitchblende, silicates vanadate, monazite and lignite sands and phosphates of uranium [4]. Uranium is toxic chemically radiologically, relying on concentration, exposure route, chemical nature, exposure period, solubility of uranium compound, and route of elimination from the body [5]. Uranium often classified as a contaminant particularly with drinking water. The most widely known radionuclides that present in drinking water are uranium, radium and radon. Uranium is a radioactive mineral which is

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occurring naturally can be found in particular kinds of rocks and soils. Water that moves through and over soil and rock compositions dissolves many compounds and minerals, including uranium and as such different quantities of it are existing in almost all the water sources. Drinking water that contains uranium can lead to adverse effects of human health. Because of biodegradability is not found in its nature, the heavy metals like uranium heap up in vital human organs and exert progressively growing toxic actions [6]. Particularly, long-run intake of uranium and some other heavy metals may make an increase in the risks of contracting kidney damage, cancer and cardiovascular diseases [7,8], whereas the experimental evidence indicate that the respiratory and reproductive systems are also subject to get affected by uranium exposure [9]. The systems of water which are vulnerable to this kind of contamination are required to go through an extreme monitoring for radioactive contamination to make sure that the drinking water is totally safe. The uranium estimation in water may also be a key for the hydro geochemical prospection for uranium to assess the health risks and also for mitigating processes. Taking into consideration the above mentioned factors, there was an attempt conducted to evaluate the uranium content in some samples of drinking water. Al-Manathera and Al-Herra regions of Najaf Governorate were selected to measure the concentrations of natural uranium in the samples of faucet water for several reasons, including the possibility of the effect of faucet water on the geological nature of these areas because of its presence near the natural uranium mine in Abu-Sakhir, its exposure to bombardment and environmental neglect more than the other cities, and the lack of radiation environmental studies around it, in addition to the fact that most of its areas are agricultural and chemical, and pesticides are used frequently compared with other areas in the province. The measurements of Uranium concentrations in water samples have been conducted worldwide in the recent past [10–13]. In this study, we have used SSNTDs type CR-39 detector for the uranium concentrations microanalysis of in tap water samples collected from some locations at Al-Manathera and Al-Herra, regions of Al-Najaf, Iraq. Also, the uranium isotopes (^{238}U, ^{235}U and ^{234}U) and the annual effective dose were calculated in all samples of tap water under study.

2. Area of study

The study focuses on an area located in the south west of Najaf city in Iraq as shown in Fig. 1. It is situated 18 km from Najaf and 22 km from west of Al-Kufa town. It is located within the southern part of Najaf sea. Al-Manathera city is bounded by 31.9089267°N north latitudes and 44.4868093°E east longitude, while Al-Herra city is bounded by 31.5300°N north latitudes and 44.2700°E east longitude. The area surface is semi plane of new depositional which contains a mixture of soft sands and clays along with vegetal organic materials resulted from remnants of grass, plants and trees.

3. Materials and methods

3.1. Sampling collection and sample sites

40 tap water samples were collected from twenty two major regions at Al-Manathera and Al-Herra area of Al-Najaf, Iraq in October–December 2016. Uranium concentrations of naturally occurring radionuclides in tap water samples were measured for Al-Manathera and Al-Herra regions which it shown in Fig. 2 and Table 1. The measurement of uranium concentrations in tap water samples were collected according to a systematic selection from different sites, two samples average from each point. The volume of samples texture for all samples was very similar. After collecting samples, each one was kept in a plastic cup and labeled according to its location. The collected samples were transferred to labeled closed plastic cup and sent to the laboratory of radiation detection and measurement in the physics department, Faculty of science, university of Kufa.

3.2. Experimental techniques

In this work, the methods adopted to measure the concentrations of uranium for the tap water samples is well known by the standard source methods. The Uranium standard solutions preparation was conducted by use uranium Octoxide U_3O_8 [14]. The concentrations of uranium in the standard solution were measured using special uranium dosimeter that can be shown in Fig. 3. The exposure time was seventy days for uranium standard solution. After 70 days, CR-39 solid state detectors were etched in a solution of (6.25 N) NaOH at a temperature of (60 °C) for (5 h), then the CR-39 tracks density were counted using an optical microscope. This procedure was applied to all the samples, including the standard samples [14].

The CR-39 tracks density (ρ) (track/cm^2 h) in the standard was calculated in accordance with the following relation [15]:

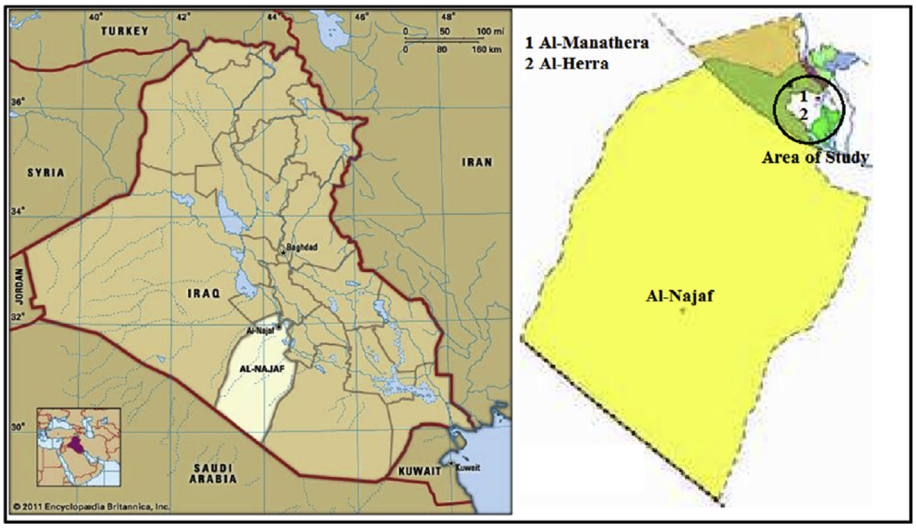

Fig. 1. Map of study area.

$$\text{Track density } (\rho) = \frac{\text{Average number of total pits (tracks)}}{\text{Area of field}(\text{cm}^2)} \quad (1)$$

The concentrations of uranium in the drinking water (ppb or μg/L) are measured using special uranium dosimeters as shown in Fig. 3. The uranium concentrations in the samples of drinking water assessment using calibration curve show in Fig. 4, according to the relationship [10]:

$$\frac{C_x}{\rho_x} = \frac{C_s}{\rho_s} \quad (2)$$

where, C_x and C_s are uranium concentrations in unidentified and standard samples, respectively, ρ_x and ρ_s are track density in unknown and standard samples, respectively.

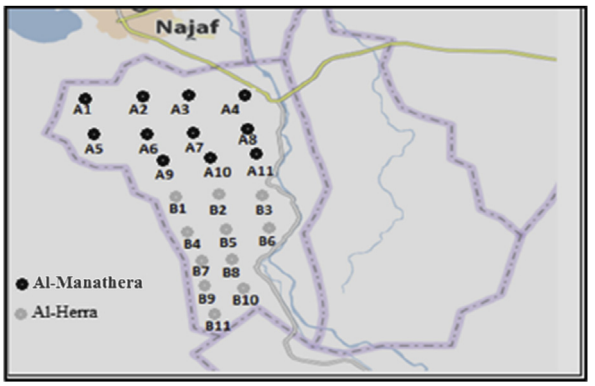

Fig. 2. Map showing study area and the sampled points.

3.3. Calculations

Uranium existed in water is regarded as natural Uranium, apparently that is the particular merit for natural Uranium activity which is 25.4 Bq/mg and containing three kinds of uranium isotopes (^{238}U, ^{235}U and ^{234}U). That activity can be calculated for these isotopes by determining the specific activity and the

Table 1
The studied sites in Al-Manathera and Al-Herra.

No.	Name of regions	Name of location	Sample code
1	Al-Manathera	Al-Zahraa	A1
2		Al-Askri	A2
3		Al-Shuhada	A3
4		Al-Jameia	A4
5		Al-Zohour	A5
6		Al-Amar	A6
7		Al-Hadi	A7
8		Al-Khawarnaq	A8
9		Al-Jamhouri	A9
10		Al-Srai	A10
11		Al-Awqaf	A11
12	Al-Herra	Al-Kuwait	B1
13		Al-Salam	B2
14		Al-Zohour	B3
15		Al-Nasr	B4
16		Al-Nouman	B5
17		Al-Zahraa	B6
18		Al-Sadiq	B7
19		Al-Yaqeen	B8
20		Al-Khadhraa	B9
21		Al-Hussein	B10
22		Al-Sunaeya zone	B11

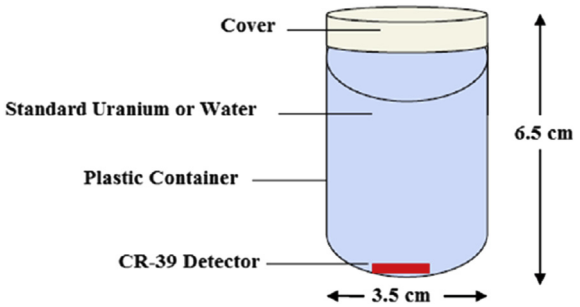

Fig. 3. Special uranium dosimeters [14].

mass fraction of them (illustrated in Table 2) and using the equation [10,16]:

$$A\left(\frac{Bq}{L}\right) = UC\left(\frac{mg}{L}\right) \times I.A.M(\%) \times S.P.A.\left(\frac{Bq}{mg}\right) \quad (3)$$

where, A is the specific activity (Bq/L), I.A.M is Isotopic Affluence Mass fraction, and S.P.A is the specific activity [17].

The annual effective dose, E_T (Sv/y), to the population (after calculated the ^{238}U, ^{235}U and ^{234}U, that emanated from the drinking water ingestion), can be reached according to [18]:

$$E_T\left(\frac{Sv}{y}\right) = A\left(\frac{Bq}{L}\right) \times 365\left(\frac{d}{y}\right) \times C_w\left(\frac{L}{d}\right) \times e(g)\left(\frac{Sv}{Bq}\right) \quad (4)$$

where, e(g) is the dose coefficients (Sv/Bq) for ^{238}U (4.5×10^{-8}), ^{235}U (4.7×10^{-8}) and ^{234}U (4.9×10^{-8}), C_w is consumption rate of water (2 L/d) [21].

4. Results and discussion

The uranium concentrations results and daily uranium intake estimation in the considerable amount

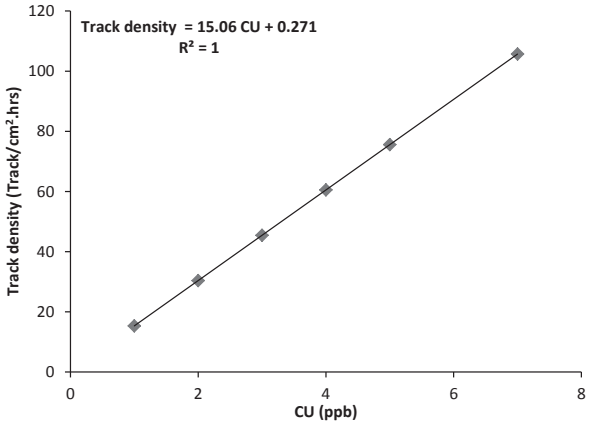

Fig. 4. Calibration curve to measure uranium concentration in water [14].

Table 2
Radioactive properties of natural uranium isotopes [17–20].

Isotope	Specific activity for Uranium (Bq/mg)	Isotopic Affluence Mass fraction (I.A.M.) (%)
^{238}U	12.44	99.2745
^{235}U	80	0.72
^{234}U	230,700	0.0055

of tap water samples taken from different places at Al-Manathera and Al-Herra regions of Al-Najaf, Iraq are reported in Tables 3 and 4. Average of Uranium concentrations in water ranged from 0.254 ± 0.069 μg/l to 3.74 ± 0.308 μg/l for Al-Manathera regions, with an average of 1.26 ± 0.162 μg/l. While the average of Uranium concentrations for Al-Herra regions ranged from 0.643 ± 0.118 μg/l to 2.31 ± 0.199 μg/l, with an average of 1.17 ± 0.424 μg/l. Also, Tables 3 and 4 show the results of average daily uranium intake in Al-Manathera and Al-Herra regions were 2.54 ± 0.325 μg/d and 2.23 ± 0.316 μg/d respectively. The health and environmental protection bodies have recommended a limit for uranium in drinking water for human beings uses. Also, ICRP has recommended that a 1.9 μg/L of uranium in water as safe level. From Fig. 5, it is show that, the uranium concentrations average value in tap water at Al-Manathera regions is larger than at Al-Herra regions and all average value for two regions under study were lower than the recommended value of ICRP [21], in which the average daily intake of uranium is high for some locations, but it remains within the limits recommended by EPA [22]. These levels were determined to represent a concentration causing no harm and risk to the health along the lifetime drinking of water. Therefore, the water suppliers of public community must be conformed to the maximum contaminated limits (MCL) recommended by these various Nation-wide and International-wide organizations.

Natural uranium that is present in water regarded as natural uranium and through knowing that the specific activity for natural Uranium is 25.4 Bq/mg [8] and also by including three kinds of uranium isotopes which are ^{238}U, ^{235}U and ^{234}U, the activity can be calculated for these isotopes using equation (3) and information about the specific activity and mass fraction in Al-Manathera regions and Al-Herra regions is given in Tables 5 and 6 respectively. The average value of uranium isotopes activities in tap water samples collected from Al-Manathera regions are given in Table 5, which show that the activities of ^{238}U, ^{235}U, ^{234}U and uranium natural in taps water were 1.56 ± 0.198 Bq/l, 0.072 ± 0.009 Bq/l, 1.58 ± 0.202 Bq/l and 3.22 ± 0.408 Bq/l respectively. While, the average value

Table 3
Uranium concentration and daily uranium intake in tap water at Al-Manathera regions.

No.	Sample code	Uranium concentration (μg/L)		Daily uranium intake (μg/d)	
		Value ± S.D	Average ± S.D	Value ± S.D	Average ± S.D
1	A1	3.70 ± 0.307	3.74 ± 0.308	7.41 ± 0.614	7.48 ± 0.617
		3.78 ± 0.310		7.56 ± 0.620	
2	A2	1.96 ± 0.219	1.53 ± 0.190	3.93 ± 0.439	3.08 ± 0.381
		1.11 ± 0.161		2.23 ± 0.323	
3	A3	0.907 ± 0.144	1.19 ± 0.166	1.81 ± 0.288	2.38 ± 0.332
		1.48 ± 0.188		2.96 ± 0.376	
4	A4	1.01 ± 0.153	1.14 ± 0.163	2.03 ± 0.306	2.28 ± 0.326
		1.27 ± 0.173		2.54 ± 0.346	
5	A5	0.822 ± 0.136	0.822 ± 0.136	1.64 ± 0.272	1.64 ± 0.272
6	A6	1.86 ± 0.212	1.86 ± 0.212	3.72 ± 0.425	3.72 ± 0.425
7	A7	1.25 ± 0.172	1.07 ± 0.157	2.50 ± 0.344	2.15 ± 0.315
		0.901 ± 0.143		1.80 ± 0.287	
8	A8	1.11 ± 0.161	0.861 ± 0.138	2.23 ± 0.323	1.72 ± 0.277
		0.612 ± 0.115		1.22 ± 0.231	
9	A9	0.498 ± 0.103	0.498 ± 0.103	0.997 ± 0.206	0.997 ± 0.206
10	A10	0.254 ± 0.069	0.254 ± 0.069	0.509 ± 0.139	0.509 ± 0.139
11	A11	0.515 ± 0.105	1.00 ± 0.147	1.03 ± 0.210	2.01 ± 0.294
		1.49 ± 0.189		2.99 ± 0.378	
Average ± S.D		1.26 ± 0.162		2.54 ± 0.325	

Table 4
Uranium concentration and daily uranium intake in tap water at Al-Herra regions.

No.	Sample code	Uranium concentration (μg/L)		Daily uranium intake (μg/d)	
		Value ± S.D	Average ± S.D	Value ± S.D	Average ± S.D
1	B1	1.02 ± 0.154	1.03 ± 0.155	2.05 ± 0.308	2.07 ± 0.310
		1.04 ± 0.156		2.09 ± 0.312	
2	B2	0.765 ± 0.131	1.26 ± 0.169	1.53 ± 0.262	2.53 ± 0.338
		1.77 ± 0.207		3.54 ± 0.414	
3	B3	0.986 ± 0.150	0.972 ± 0.149	1.97 ± 0.301	1.94 ± 0.299
		0.958 ± 0.148		1.91 ± 0.297	
4	B4	0.805 ± 0.134	1.05 ± 0.155	1.61 ± 0.269	2.11 ± 0.310
		1.31 ± 0.176		2.62 ± 0.352	
5	B5	0.521 ± 0.105	0.643 ± 0.118	1.04 ± 0.211	1.28 ± 0.236
		0.765 ± 0.131		1.53 ± 0.262	
6	B6	1.83 ± 0.211	1.33 ± 0.174	3.66 ± 0.422	2.66 ± 0.348
		0.833 ± 0.137		1.66 ± 0.274	
7	B7	0.663 ± 0.121	1.43 ± 0.177	1.32 ± 0.242	2.86 ± 0.354
		2.20 ± 0.233		4.40 ± 0.466	
8	B8	0.839 ± 0.138	0.919 ± 0.145	1.67 ± 0.276	1.83 ± 0.290
		1.00 ± 0.152		2.00 ± 0.304	
9	B9	0.935 ± 0.146	0.967 ± 0.149	1.87 ± 0.293	1.94 ± 0.299
		1.00 ± 0.152		2.01 ± 0.305	
10	B10	0.589 ± 0.113	0.979 ± 0.146	1.17 ± 0.226	1.95 ± 0.293
		1.37 ± 0.180		2.74 ± 0.361	
11	B11	1.26 ± 0.172	2.31 ± 0.199	2.53 ± 0.345	3.37 ± 0.400
		2.10 ± 0.227		4.21 ± 0.455	
Average ± S.D		1.17 ± 0.424		2.23 ± 0.316	

of uranium isotopes activities in tap water samples collected from Al-Herra regions are given in Table 6, which show that the activities of ^{238}U, ^{235}U, ^{234}U and uranium natural in taps water were 1.37 ± 0.194 Bq/l, 0.063 ± 0.008 Bq/l, 1.38 ± 0.196 Bq/l and 2.83 ± 0.401 Bq/l respectively.

The results of the annual effective dose due to uranium isotopes (^{238}U, ^{235}U, ^{234}U) and average total

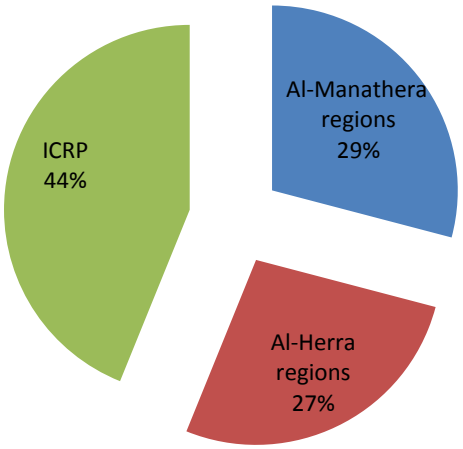

Fig. 5. Percentage of the average value of uranium concentrations in tap water at Al-Manathera regions, at Al-Herra regions and ICRP.

annual effective dose for taps water to the adult members of the population in Al-Manathera and Al-Herra regions are given in Tables 7 and 8. The results of the E_T for ^{238}U, ^{235}U and ^{234}U of the tapes water samples of Al-Manathera regions were 51.66 ± 6.61 μSv/y, 2.50 ± 0.321 μSv/y and 56.75 ± 7.08 μSv/y respectively, while the results of total average the ET has the minimum and maximum values as 0.022 ± 0.006 mSv/y to 0.325 ± 0.026 mSv/y with an overall average value of 0.110 ± 0.013 mSv/y as shown in Table 7. Whereas Table 8 showed the results of the for ^{238}U, ^{235}U and ^{234}U of the tapes water samples of Al-Herra regions were 45.38 ± 6.41 μSv/y, 2.20 ± 0.312 μSv/y and 49.85 ± 7.05 μSv/y respectively, while the results of total average the E_T has the minimum and maximum values as 0.055 ± 0.010 mSv/y to 0.146 ± 0.017 mSv/y with an overall average value

Table 5
Activity of uranium isotopes in tap water at Al-Manathera regions.

No.	Sample code	Average uranium isotopes Bq/l			
		^{238}U	^{235}U	^{234}U	Natural
1	A1	4.61 ± 0.381	0.215 ± 0.017	4.65 ± 0.384	9.49 ± 0.783
2	A2	1.90 ± 0.235	0.088 ± 0.010	1.92 ± 0.237	3.91 ± 0.483
3	A3	1.47 ± 0.174	0.068 ± 0.009	1.48 ± 0.206	3.02 ± 0.421
4	A4	1.40 ± 0.204	0.065 ± 0.008	1.42 ± 0.202	2.89 ± 0.414
5	A5	1.01 ± 0.168	0.047 ± 0.007	1.02 ± 0.169	2.08 ± 0.346
6	A6	2.29 ± 0.263	0.107 ± 0.012	2.31 ± 0.265	4.72 ± 0.540
7	A7	1.32 ± 0.194	0.061 ± 0.008	1.34 ± 0.196	2.73 ± 0.400
8	A8	1.06 ± 0.170	0.049 ± 0.007	1.07 ± 0.172	2.19 ± 0.351
9	A9	0.615 ± 0.127	0.028 ± 0.005	0.621 ± 0.128	1.26 ± 0.261
10	A10	0.314 ± 0.086	0.014 ± 0.009	0.317 ± 0.087	0.646 ± 0.177
11	A11	1.23 ± 0.181	0.057 ± 0.008	1.25 ± 0.183	2.55 ± 0.373
Average ± S.D		1.56 ± 0.198	0.072 ± 0.009	1.58 ± 0.202	3.22 ± 0.408

Table 6
Activity of uranium isotopes in tap water at Al-Herra regions.

No.	Sample code	Average uranium isotopes Bq/l			
		^{238}U	^{235}U	^{234}U	Natural
1	B1	1.27 ± 0.191	0.059 ± 0.008	1.28 ± 0.193	2.63 ± 0.393
2	B2	1.56 ± 0.208	0.072 ± 0.009	1.57 ± 0.210	3.21 ± 0.429
3	B3	1.19 ± 0.184	0.055 ± 0.008	1.20 ± 0.186	2.46 ± 0.382
4	B4	1.30 ± 0.191	0.060 ± 0.008	1.31 ± 0.193	2.68 ± 0.394
5	B5	0.794 ± 0.145	0.037 ± 0.006	0.801 ± 0.147	1.63 ± 0.300
6	B6	1.64 ± 0.214	0.076 ± 0.010	1.65 ± 0.217	3.38 ± 0.442
7	B7	1.76 ± 0.218	0.082 ± 0.009	1.78 ± 0.220	3.63 ± 0.449
8	B8	1.13 ± 0.179	0.052 ± 0.007	1.14 ± 0.180	2.33 ± 0.368
9	B9	1.19 ± 0.184	0.055 ± 0.008	1.20 ± 0.186	2.46 ± 0.379
10	B10	1.20 ± 0.181	0.056 ± 0.008	1.22 ± 0.183	2.48 ± 0.372
11	B11	2.08 ± 0.246	0.096 ± 0.011	2.09 ± 0.249	4.27 ± 0.507
Average ± S.D		1.37 ± 0.194	0.063 ± 0.008	1.38 ± 0.196	2.83 ± 0.401

Table 7
Annual effective dose to the public during the year at Al-Manathera regions.

No.	Sample code	Average of annual effective dose μSv/y			Total mSv/y
		^{238}U	^{235}U	^{234}U	
1	A1	151.87 ± 12.52	7.39 ± 0.610	166.81 ± 13.75	0.325 ± 0.026
2	A2	62.61 ± 7.72	3.04 ± 0.376	68.77 ± 8.48	0.134 ± 0.016
3	A3	48.44 ± 6.73	2.35 ± 0.328	53.21 ± 7.40	0.104 ± 0.014
4	A4	46.37 ± 6.62	2.25 ± 0.322	50.93 ± 7.27	0.099 ± 0.014
5	A5	33.36 ± 5.53	1.62 ± 0.269	36.64 ± 6.08	0.071 ± 0.011
6	A6	75.51 ± 8.64	3.67 ± 0.420	82.94 ± 9.49	0.162 ± 0.018
7	A7	43.72 ± 6.39	2.12 ± 0.308	48.02 ± 7.02	0.093 ± 0.013
8	A8	35.08 ± 5.62	1.70 ± 0.273	38.54 ± 4.17	0.075 ± 0.012
9	A9	20.23 ± 4.18	0.985 ± 0.203	22.22 ± 4.59	0.043 ± 0.008
10	A10	10.32 ± 2.83	0.503 ± 0.138	11.34 ± 3.11	0.022 ± 0.006
11	A11	40.84 ± 5.97	1.98 ± 0.290	44.86 ± 6.56	0.087 ± 0.,012
Average ± S.D		51.66 ± 6.61	2.50 ± 0.321	56.75 ± 7.08	0.110 ± 0.013

Table 8
Annual effective dose to the public during the year at Al-Herra regions.

No.	Sample code	Average of annual effective dose μSv/y			Total mSv/y
		^{238}U	^{235}U	^{234}U	
1	B1	42.11 ± 6.29	2.04 ± 0.306	46.25 ± 6.91	0.090 ± 0.013
2	B2	51.43 ± 6.86	2.50 ± 0.334	56.50 ± 7.53	0.110 ± 0.014
3	B3	39.46 ± 6.07	1.92 ± 0.295	43.34 ± 6.66	0.084 ± 0.012
4	B4	42.92 ± 6.30	2.09 ± 0.307	47.19 ± 6.97	0.092 ± 0.013
5	B5	26.10 ± 4.80	1.27 ± 0.233	28.67 ± 5.27	0.055 ± 0.010
6	B6	54.09 ± 7.06	2.63 ± 0.344	59.41 ± 7.76	0.115 ± 0.014
7	B7	58.12 ± 7.18	2.83 ± 0.349	63.84 ± 7.88	0.124 ± 0.015
8	B8	37.39 ± 5.88	1.81 ± 0.286	41.07 ± 6.46	0.080 ± 0.012
9	B9	39.46 ± 6.06	1.91 ± 0.295	43.34 ± 6.66	0.084 ± 0.012
10	B10	39.80 ± 5.96	1.93 ± 0.290	43.72 ± 6.55	0.085 ± 0.012
11	B11	68.36 ± 8.12	3.33 ± 0.403	75.09 ± 8.91	0.146 ± 0.017
Average ± S.D		45.38 ± 6.41	2.20 ± 0.312	49.85 ± 7.05	0.096 ± 0.013

of 0.096 ± 0.013 mSv/y. Fig. 6 shows the results of the total average of annual effective dose of the taps water samples of Al-Manathera regions is larger than of Al-Herra regions and two regions under study were only a minor fraction of recommended ICRP annual effective dose of 1 mSv [23].

In the end, and as in the measurements of uranium concentration and the findings of total average of annual effective dose were illustrated that the Al-Manathera regions waters have values larger than tap water of Al-Herra regions. However, all findings comply with internationally permissible limits [21–23]. Table 9 gives the uranium concentration in drinking water to some countries in around the world. From this table, it can be noted that the uranium concentration in drinking water for neighboring countries of Iraq, such as Jordan ranges from 0.04 to 14.00 μg/L with an average 2.4 μg/L, concerning Turkey ranges from 0.24 to 17.65 μg/L, and for Kuwait ranges from

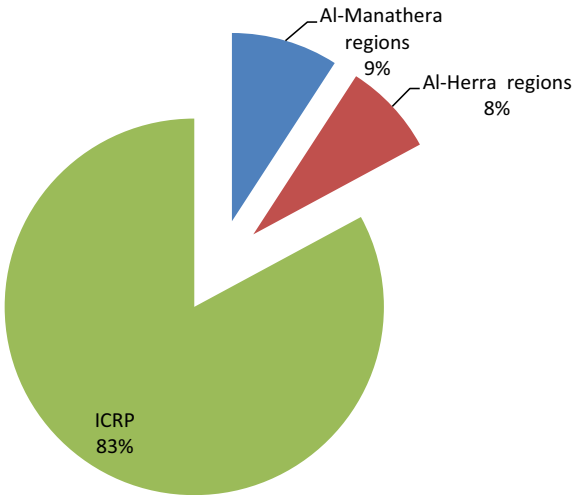

Fig. 6. Percentage of the total average of annual effective dose in tap water at Al-Manathera regions, at Al-Herra regions and ICRP.

Table 9
Range of uranium concentrations in drinking water worldwide [23].

No.	Country		Range of uranium concentrations (μg/L)	Average (μg/L)
1	Canada		0.05–4.21	0.40
2	Argentina		0.04–11.0	1.3
3	Jordan		0.04–14.00	2.4
4	Turkey		0.24–17.65	8.9
5	Kuwait		0.02–2.48	1.5
6	This study	Al-Manathera	0.67–2.29	1.26
		Al-Herra	0.50–1.66	1.17

0.02 to 2.48 μg/L. In addition, uranium concentrations in drinking water for some international countries and some neighboring countries, and one can easily note that our results are comparable with other values.

5. Conclusions

Uranium concentration, uranium isotopes (^{238}U, ^{235}U, ^{234}U and total natural), daily uranium intake and annual effective dose due to uranium isotopes and total average in taps waters used for drinking in Al-Manathera regions were larger than in Al-Herra regions. Also it is found that the Uranium concentration values in most tap water samples are lower than the recommended value of ICRP (1.9 μg L^{-1}). The highest average annual effective dose for natural Uranium was found only as a minor proportion of recommended ICRP annual effective dose of 1 mSv/y. Therefore, the drinking water at the study area in Al-Najaf governorate can be considered as safe as long as uranium concentration is concerned and does not constitute a danger or hazard to the citizens.

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