^{238}U activity Measurement by CR- 39 for some water stations in Baghdad City

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Abstract

The study aims to provide a base-line data for the effective monitoring of ^{238}U content in water investigated areas: AL-Rasafah (R), AL-Bladiat (B), AL-Whdah (Wh), AL-Rasheed (Ra) and AL-Jadriya(J). Attempts were made in order to measure the ^{238} U concentration level in 10 samples of a station water taken form first and final stages. The content of ^{238}U was obtained by using CR-39 technique. Results showed that the uranium concentration (uc) for ^{238}U the range was from (2.50µg/l) in (J1) to (4.90µg/l) in (R1) for the first stage (river water) with an average of (3.66 µg/l), while the UC in the final stage (drinking water) at all water stations ranged from (1.32 µg/l) in (J2) to (1.95) µg/l in (R2) with an average of (1.68) µg/L), while the activity of ^{238}U for water samples in the final stage at all water stations from (16.30 mBq/l) in (J2) to (24. 08 mBq/l) in (R2), with an average (20.84 mBq/l). The values of UC for ^{238}U in all water samples for both stages were less than (WHO) values which was in the safe limit (15 µg/l).The results can be reflected by the Tigris River water cleanliness against radioactivity contamination.

Keywords: Natural radioactivity, CR-39, ^{238}U**,** activity, WHO**.**

قياس نشاط اليورانيوم 238 بواسطة الـ (CR-39) لبعض محطات المياه في مدينة بغداد

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الخلاصة

تهدف الدراسة إلى توفير بيانات أساسية للرصد الفعال لليورانيوم(238 U) في مواقع فحص المياه ، والتي تشمل محطات تصفية ماء الرصافة (R) ، والبلديات (B) ، والوحدة (Wh) ، و الرشيد (Ra.) ، والجادرية (J). حيث أجريت محاولات لقياس مستوى تركيز اليورانيوم (238 U) في 10 عينات من مياه محطات التصفية حيث اخذت من المرحلة الأولى والمرحلة النهائية. تم الحصول على محتوى (238 U) باستخدام تقنية CR-39 وهواحد الكواشف الصلبة النووية (Solid State Nuclear Track Detectors) (SSNTDs).

أظهرت النتائج أنه في المرحلة الأولى (مياه النهر) كان تركيز اليورانيوم لـ (238 U) يتراوح من (2.50 ميكروغرام / لتر) في محطة الجادرية(J1) إلى (4.90 ميكروغرام / لتر) في محطة الرصافة (R1). بمتوسط (3.66 ميكروجرام / لتر) في مياه النهر. تراوحت نسبة UC في المرحلة النهائية (مياه الشرب) في جميع محطات المياه من (1.32 ميكروغرام / لتر) في محطة الجادرية(J2) إلى (1.95 ميكروغرام / لتر في محطة الرصافة (R2). بمتوسط (1.68) ميكروغرام / لتر ، بينما كان نشاط (238 U) لعينات المياه في المرحلة النهائية في جميع محطات المياه من (16.30 ملي بيكريل / لتر) في محطة الجادرية (J2) إلى (24.08 ملي بيكريل / لتر) في محطة الرصافة(R2) بمتوسط (20.84 ملي بيكريل / لتر). تبين ان قيم تراكيز لـ U238 في جميع عينات المياه لكلتا المرحلتين أقل من قيمة (WHO)(منظمة الصحة العالمية) وهي الحد الآمن (15 ميكروغرام / لتر) ويمكن أن تنعكس النتائج على نظافة مياه نهر دجلة من التلوث الإشعاعي.

الكلمات المفتاحية: النشاط الاشعاعي الطبيعي، كاشف الاثر النووي، اليورانيوم 238، النشاط ، منظمة الصحة العالمية

1. Introduction

Water is an essential element to human life as the air .Thus, it is important to investigate the radio nuclides level in water. (2.5- 3 l /d) it is drinking water full biological value that human needs, the value cab be divided as follows: (1.5L) drinking , 0.7 foods and 0.3 oxidation within the cells (R. J. Isehak, 2001). Drinking water may have three radioactive chains, Uranium, Thorium, Actinium, including the natural Radium, Uranium elements, as well as Radon gas. These elements have diverse biological affect that damage human body, e.g. Radium converges in bones that can cause cancer. Uranium has a poisonous effect on the kidneys and causes bones cancer (Radionuclide contamination ,2010). Uranium is a natural radioactive element. In its pure form, it is a silver-white, lustrous, dense and weakly radioactive metal. Metallic uranium has a high density of 19 g/cm^3. It is found in the earth's crust at an average concentration about 2 ppm (approximately 1 pCi/g) (K.Rankana ,1963) .Naturally, uranium (U_{nat}) consists of three isotopes (^{234}U, ^{235}U and ^{238}U), all of which decay by both alpha and gamma emissions. ^{238}U isotope is the most abundant by weight 99.27% with ^{235}U, ^{234}U isotopes constituting about 0.72% and 0.0054%, respectively (The Health Physics society ,2005). Uranium presents in the environment as a result of leaching from natural deposits, release in mill tailings, emissions from the nuclear industry, the combustion of coal and other fuels. Additional contamination of arable soils is caused by the use of phosphate fertilizers due to the relatively high uranium levels in phosphate ores 30 - 200 ppm (United Nations,2005). During natural geological processes such as the partial melting and fractional crystallization of the Earth's mantle, uranium becomes preferentially concentrated in the liquid phase and consequently becomes incorporated into the more silica-rich products(Mazin .M. Attiyah ,2013). Several of previous studies were made by similar techniques of current studies as follow:

Jaspal Singha, et. al. in 2003 . The U-content obtained was compared in two ways; the first technique is the fission track, uranium concentrations range was between (11.07-113.70) ppb, while the second technique was laser fluorometry, uranium concentrations range was between (15.3181.35) ppb,while Mustafa Arab Al-Baidhani in 2006 . Determined the radioactivity in soil and water in Baghdad, Karbala and Basra samples using SSNTD, the UC for water in Baghdad was in range 0.67-1.92 ppm and average 1.33 ppm while in Basra the range was 1.22-2.12 ppm and the average 1.7ppm. while Rohit Mehra, et. al. in 2007 .007 Uranium studies in water samples in Malwa region of Punjab, using the track etching technique, The uranium content in the water was between (5.41-43.39) g liters for each of Bernala and Hreik Tower, respectively, averaged 17.33 g geometric liters, Whereas Singh H. in 2009 . UC in drinking water samples Using the SSNTDS, Punjab India, It was found that uranium content in the water samples was varied from 0.09+ 0.08 to 63+0.21 ppb, whille GianiZail Singh in 2011 . Uranium concentration was determined in groundwater samples in Bhiwani, Hisarregions, Fatehbad and Sirsa in western Haryana, India. A trace detector technique was used to estimate the uranium content in water samples in range from 6.37 mg / L (SERA) to 43.31 mg / L (animal) with an average value 19.14 mg /L for the study area: Uranium concentration in all studied samples was found above the recommended value 1.9 µg / L (ICRP) but most values were comparable to the safe limit of 15 µg / L (WHO, 2008) finally ,Sami Salman Chiad, in 2012 . determined radon concentrations in soil and water samples using the CR-39 technique, the results indicated that there was the highest concentration in Basra governorate (167.28 Bq/m3), (0.479Bq/l) for soil and water, respectively.

2. Areas under Study

All of Iraqi population depends on Tigris and Euphrates rivers in all uses, including drinking water, which stems from Turkey, and lies to the north of Iraq Figure (1). The study took place in Iraq Baghdad the capital where the Tigris River passes and divides it into two parts. Baghdad area is about 4555 Km^2, and its population 7,145,470 million. Baghdad is located in the center of Iraq at latitude coordinates 33° 18'03.56"N, and longitude 44°25'07.11"E, which lies between coordinates of latitude 33°31'53.29"N, and longitude 44°20'14.12"E at the entrance to the Tigris River from the north, coordinated latitude 33° 5'74.43 "N, and longitude 44° 31'45.44" East, at the exit of the Tigris River from the south. Baghdad's range altitude above sea level ranges is between 29m - 44m. The length of the Tigris River within the city of Baghdad is about 58.5 km measured from the outer of the “Tourist Island of Baghdad”, and up to 3 km after confluence Diyala River. There are 34 distinctive half-bow with different diameters in this part of the river. The Tigris River width within the city range is between 190 and 500 meters, and its water speed is 1.42 m /s at a high level and 0.45 m/s low level. The components of the river’s bottom are soft sand, silt, and clay. The Tigris River has five pours located on the eastern side, called: Kabur, Zab up, Zab down, Al- Azim and Diyala.

Conducting these tributaries in different geographical areas leads to the difference in the quality of its water, which in turn affects physically and chemically on the waters ‘ Tigris River quality’.

Figure (1): Baghdad map

3. Sampling strategy and collection samples

It has been studied five purification stations in Baghdad that distribute water to most parts of the city, In Al-Rusafa and extend along the Tigris River from north to south, as shown in Figure (2).

The water purification station completed its works in several stages. The first one is the withdrawal of water from the river and collects it in tanks. The second is the river water deposition process with the station. The third depends on uses sand filters to filter the water, and the fourth stage is to repeat the deposition process and then add chlorine. The waters samples have been taken from the first stage (river water) and final stage (drinking water) of the refine processes. The total number of water samples drawn from the purification stations was 10 samples, as shown in Table (1).

Table (1): Collecting water samples from the stations of Baghdad.

N.	Name station	Code	First stage (river water)	Final stage (drinking water)
1	AL-Rusafa	R	R1	R2
2	AL-Baldiat	B	B1	B2
3	AL-Wahda	WH	WH1	WH2
4	AL- Rasheed	RA	RA1	RA2
5	AL-Jadryh	J	J1	J2

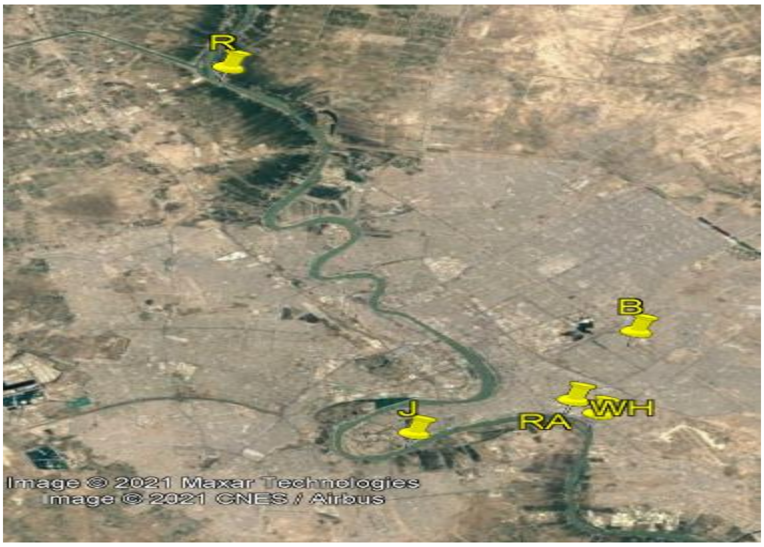

Figure (2): The locations of purification stations.

4. Materials and Methods

In this work, it has been used commercial CR-39 plastic sheets, which were presently known as the most sensitive solid state nuclear track detector (SSNTD) and characterized by low background. The detector (CR-39) has also high efficiency in recording the tracks comparing with other detectors. These detector sheets thickness were 500 μm with density of 1.32 g/cm3, they were cut into small pieces each one was 1cm × 1cm area. Pershore moulding LTD Company, U.K, made the present sheets of CR-39. The detector sheets were stored at normal laboratory conditions (Mazin .M. Attiyah , 2013 , S.C.L. Scharama and G.K. Metha, 1980) According to the information of its manufacturer, the CR-39 detector records the alpha-particles in a range of 1.2-4.8 MeV, which means, the emitted alpha-particles in a good distance from the detector could be registered (Ali A. Abojassim, 2014) Chines Optical microscope type (NOVEL) was used which is capable of giving magnifications of (400 X), where the object piece (40X) and eye piece (10X). The microscope camera was connected to a computer and the images were taken by a desktop program called (Micro Capture).

5. Experimental Part

The measurements were made with the solid state nuclear track detector (SSNTD) technique. A schematic diagram was shown in Figure (3). Each cup container was 6.5 cm height, 3.5 cm in diameter and contains (1×1) cm square of CR-39 nuclear track detector fixed at the bottom of the cup with its sensitive side up ward, as well as for the special uranium dosimeters as shown in Figure (3).

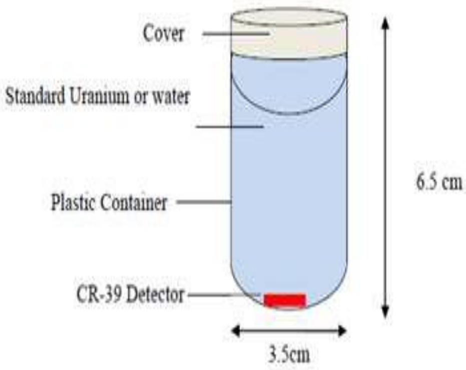

Figure (3): Special uranium dosimeters, to measure the uranium concentrations in the standard solution or water.

The exposure time was 90 days for uranium standards solution, After (90 days) (CR-39) detectors were etched in (6.25N) NaoH solution at temperature of 70 C° for (5h), then the induced CR-39 tracks density were recorded using the optical microscope as shown in Figure (4) .

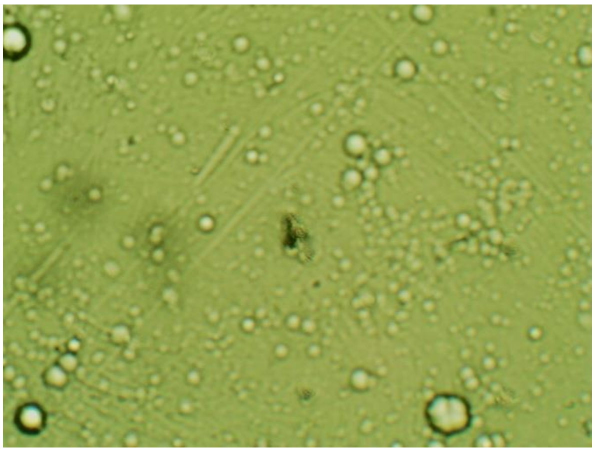

Figure (4): The tracks of α.

This procedure was used on all the samples including the standard ones. The density of the CR-39 tracks (ρ)(track/cm2.h) in the standard was calculated according to the following relation (1) (F.M. Khan, Williams and Wilkins , 1984).

Track density (ρ) = Average number of total pits (tracks) / [Numberof field view× Area of field view] (cm2) × Time (h) (1)

The uranium concentrations in water samples assessment was done by using calibration curve show in Figure (5). According to the relationship (2):

$$\mathbf{CX}\ (\mathbf{sample}) \ / \ \boldsymbol{\rho}\mathbf{X}\ (\mathbf{sample}) = \mathbf{CS}\ (\mathbf{standard}) \ / \ \boldsymbol{\rho}\mathbf{S}(\mathbf{standard})$$

$$\mathbf{CX} = \mathbf{CS}\,.\,(\boldsymbol{\rho}\mathbf{X} \ / \ \boldsymbol{\rho}\mathbf{S}) \ \ldots\ldots(2)$$

When (slope) = ρS / CS (from calibration curve in Figure (5)).

Where:

• CX: uranium concentration in unknown sample (ppm).

• CS: uranium concentration in standard sample (ppm).

• ρX: track density of unknown sample (tracks/cm2).

• ρS: track density of standard sample(tracks/cm2).

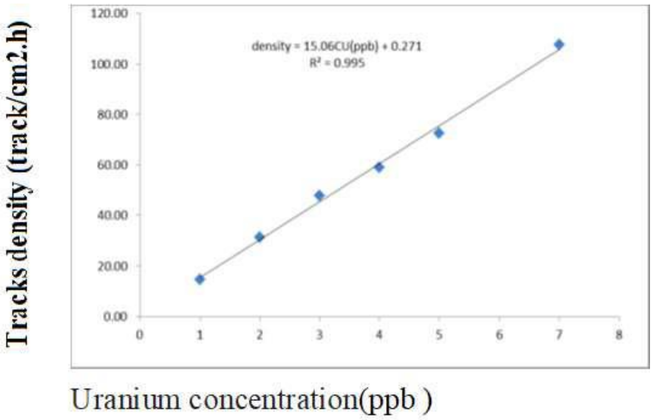

Figure (5) : Calibration curve for standard uranium (ppb).

The half-lives, specific activities, relative abundances and average energy per transformation of uranium isotopes ^{238}U, ^{235}U and ^{234}U in natural uranium are given in Table (2) **(** Majali. Mustafa Mohamed Abdel-Mahdi , 2005)

Table (2): Radioactive properties of natural uranium isotopes **(** Majali. Mustafa Mohamed Abdel-Mahdi , 2005)

Isotope	Isotope Half-life (year)	Specific activity (Bq/mg)	Isotopic abundance (%)		Average energy per transformation (MeV/Bq)		
			By mass	By activity	Alpha radiation	Beta radiation	Gamma radiation
$^{238}_{92}$U	4.51×10^9	12.44	99.274	48.2	4.26	0.010	0.001
$^{235}_{92}$U	7.1×10^8	80	0.7200	2.2	4.47	0.048	0.154
$^{234}_{92}$U	2.47×10^5	230700	0.0054	49.6	4.84	0.001	0.002

Through the percentage abundance (99.274%) and specific activity (12.44 Bq/mg) for ^{238}U isotope in Table(2), We can be calculated the relation between specific activity and concentration By using Eq. 2 (Majali. Mustafa Mohamed Abdel-Mahdi , 2005)

$$A\left(\frac{Bq}{l}\right) = \left(UC\left({}^{mg}/_{l}\right) \times I.A.M(\%)\right) \times S.P.A\left({}^{Bq}/_{mg}\right) \quad (2)$$

Where:

- A-Activity (Bq/l),
- S.P.A- Specific activity,
- I.A.M- Isotopic abundance (%) by mass fraction,
- UC- Uranium concentration (mg ⁄ l)

6. Results and Discussions

6.1. Uranium Concentration in Water (UC)

The results of the UC for ^{238}U were in the water samples that were collected from the water refinery stations in Baghdad and measured for the first stage (raw water) and final stage (drinking water) of liquidation using CR-39 techniques. These stations were: AL-Rasafah (R), AL-Bladiat (B), AL-Whdah (Wh), AL-Rasheed (Ra) and AL-Jadriya (J).

The UC of water in the first stage (river water) in all water stations ranged from 2.50µg/l in (J1) to 4.90µg/l in (R1). With an average of 3.66 µg/l. The values of UC in all water samples of the first stage were less than (WHO) value which were in the safe limit of 15 µg/l. Table (3) shows that the concentration of ^{238}U for the first stage (river water).

The UC of water in the final stage (drinking water) at all water stations ranged from 1.32 µg/l in (J2) to (1.95) µg/l in (R2) with an average of (1.68) µg/l). All the drinking water samples values were less than the WHO values, which were in the safe limit of 15 µg/l (World Health Organization (WHO) , 1998) Figure (6) shows the relationship between ^{238}UC with the first stage and the final stage (launch stage water) purification for all stations. Table (3) shows the concentration of ^{238}U for the final stage (drinking water).

Table (3): Uranium concentration in water station samples.

First stage (river water)	^{238}UC(µg/l)	Final stage (drinking water)	^{238}UC(µg/l)
R1	4.90	R2	1.95
B1	3.00	B2	1.85
WH1	4.30	WH2	1.60
RA1	3.60	RA2	1.72
J1	2.50	J2	1.32
Minimum	2.50	Minimum	1.32
Maximum	4.90	Maximum	1.95
Ave.	3.66	Ave.	1.68
WHO value safe limit[11]	15		

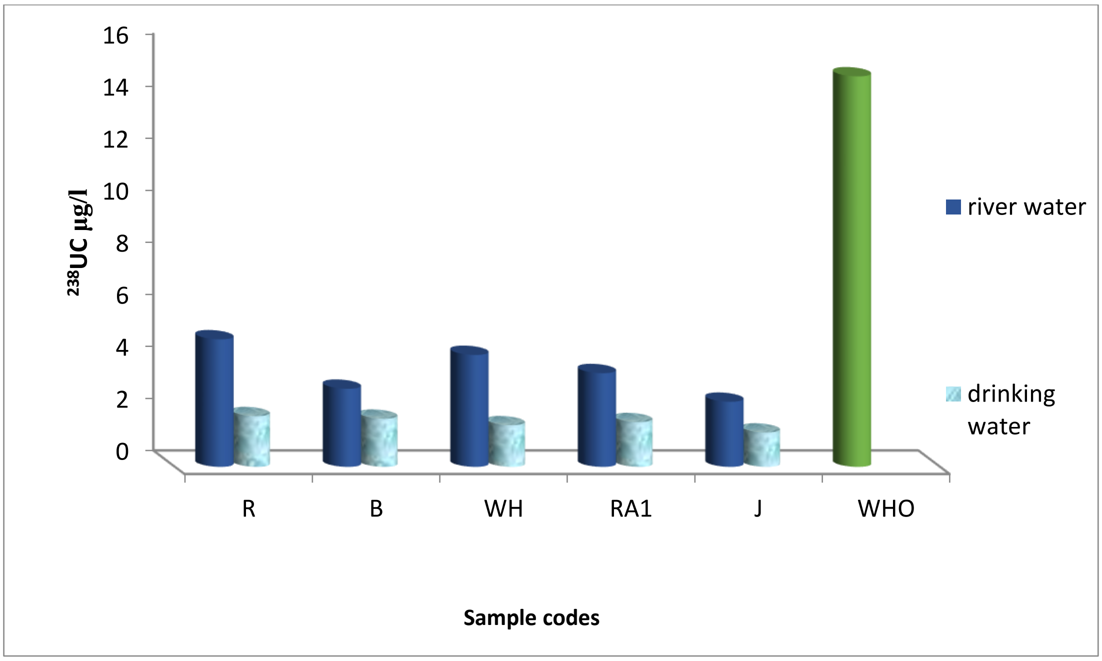

Figure (6): Showed the 238UC concentration in water stations samples (µg/l).

6.2 Measurements Activity of ^{238} Uranium Isotopes.

Uranium which was found in water considered as natural uranium, The activity for these isotopes can be calculated by using Eq(2). The specific activity used and the mass fraction are illustrated in Table (4).The activity of ^{238}U for water samples in the final stage at all water stations were from (16.30 mBq/l) in (J2) to (24. 08 mBq/l) in(R2) with an average (20.84 mBq/l). Figure (7) shows the activity value of ^{238}UC in final stage for purification stations .

Table (4): activity of the measured radionuclides in the final stage (drinking water) samples

Final stage (drinking water)	Activity of ^{238}U (mBq/l)
R2	24.08
B2	22.85
WH2	19.76
RA2	21.24
J2	16.30
Minimum	16.30
Maximum	24.08
Ave.	20.84

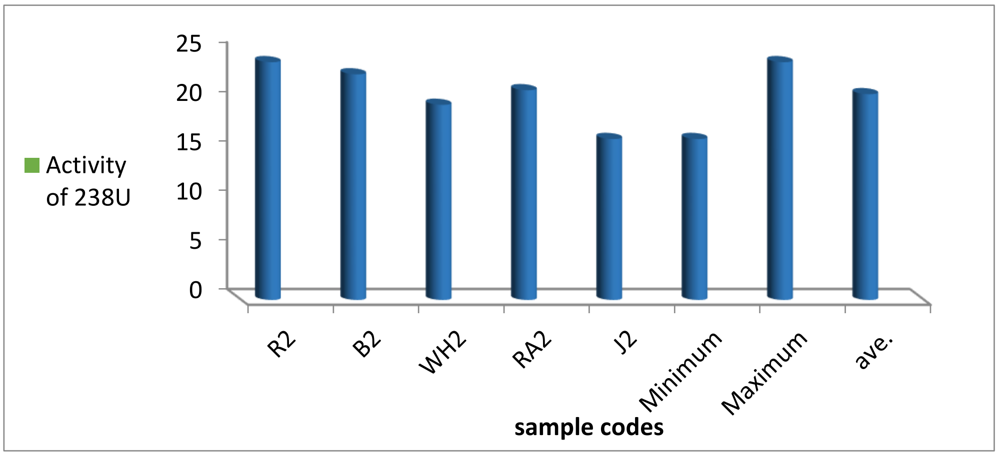

Figure (7): . the Activity of ^{238}U in drinking waters samples

7. Conclusion

This study showed that:

- The ^{238}U concentrations were measured in river water samples by CR-39. The highest concentrations were found in R1(4.9µg/l) and the lowest in J1(2.5µg/l) with an overall average (3.66µg/l).
- The ^{238}U concentrations were measured in drinking water samples by CR-39. The highest concentrations were found in R2 (1.95µg/l) and the lowest in J2(1.32µg/l) with an overall average (1.68 µg/l). By comparing the obtained values with WHO values, it was found they were in the safe limit(15 µg/l) (World Health Organization (WHO), 1998) or less.
- The ^{238}U activities were measured in drinking water samples. The highest value was found in R2 (24.08m Bq/l) and the lowest in J2(16.30m Bq/l) with an overall average (20.84m Bq/l). By comparimg with world average (10 Bq/l) (Dipak Ghosh, et. al., 2004) this showed, they were less.
- The results can be reflected the cleanliness of Tigris River water against radioactivity contamination and it safe for drinking.

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