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Evaluation of the uranium concentrations in human tissues samples by fission fragments induced using CR-39 nuclear Track detector

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ABSTRACT

Track densities and uranium concentrations were calculated for 50 human tissue samples (breast and uterus) back to patients subjected to surgical operation .These samples were collected from the educational laboratories belong to medical Baghdad city. Samples were prepared, pressed into pellet, and inserted between two pieces of CR-39 as sandwich. Neutron induced fission technique has been applied to determine uranium concentrations by irradiating the composition (detector-sample-detector) with fast neutron emanated from (Am214-Be) neutron source, to let fission tracks resulting from nuclear reaction ^{238}U (n, f) registries on CR-39 detectors. Tracks produced in the detector are enlarged, viewed, and counted by optical microscope after etching the detector by two different chemical etching technique; the conventional (water bath) and new (microwaves). For the first time in our research many etching times were be examined to approach the appropriate time for developed the potential tracks in CR-39 detector originate from uranium fissions, which is be (8)mints. The track densities calculated in microwave etching technique were slightly less than the number calculated using microwave, and the same thing applies for uranium concentrations. The mean average uranium concentrations calculated when using water bath technique were (0.062ppm) and (0.060ppm) for uterus and breast respectively. For microwave technique the mean average uranium concentrations were be (0.047ppm) and (0.039ppm) for uterus and breast respectively. Our results will agree with world uranium concentrations values calculated in human tissues. Finally, we would like to mention that the present study is considered to be very important because it affect people's health

Keywords: CR-39, uranium concentration, fission fragments, microwave etching, biological samples.

1. INTRODUCTION

Human contains several radionuclides inside their bodies coming either from continues exposed to the natural (cosmic, terrestrial and radon) and artificial radiation sources, or they are inside their bodies from birth such as potassium-40, carbon-14, lead-210.[1] Uranium, thorium and their daughter products are significant sources of natural radioactivity in the environment. Natural uranium has higher abundance in earth crust than other elements. Uranium concentration varies from region to region upon the geology of the area [2]. Radionuclides such as uranium (natural or depleted), thorium and other isotopes enters into human body mainly through three pathways ;inhalation which Is the most likely route of intake, ingestion; by drinking water , eating foods or smoking Cigarettes , and dermal contact where radionuclides enter the circulatory system through open wounds[3]. The average of uranium-238 enters the body via nutrition in regions have natural radioactivity in the world is about (5Bq) and its specific concentration estimated to be (0.15Bq/Kg) in bones and ($5x10^{-3}$ Bq/Kg) in soft tissues. While for Thorium-232 radionuclides which is concentrated in bones and increases with age, the activity concentration is about ($4x10^{-2}$ Bq/Kg) in bones and ($3x10^{-4}$ Bq/Kg) in soft tissues [4]. In addition there is radium-226 which its concentration in soft tissues is (2.7µBq) and polonium-210 which represents an important case because of its presence in the tobaccos where cigarettes contain about (15µBq) and is also present in the species that are eaten by marine biologist.[5] Small traces of uranium concentrations in human soft tissues can be detected with the help of neutrons induced fission fragments mechanism using CR-39 solid state nuclear track detectors type. Fission fragments will create tracks in the CR-39 solid detector along their paths when it's irradiated together with a sample containing a certain very high atomic number nuclei (like uranium and thorium in human soft tissues) to thermal or fast neutrons emitted from a neutron source. These fission tracks can then be enlarged by chemical etching because they are more susceptible to chemical attack than other areas of the tracks. The procedure of chemical etching were made using two techniques; chemical etching by water bath and microwave induced chemical etching at 6.25N NaOH,60º. The developed tracks viewed and counted by optical microscope to estimate an accurate number of fission events within the specimen that was deposited on track detector surface. This calculated number of fission events, given an accurate evaluation of the amount of uranium and Thorium in the original studying sample.

2. EXPERIMENTAL DETAILS

Twenty five human tissue samples (breast and uterus) taken from women have undergone surgery were be collected from the histopathology department in educational laboratories belong to the medical city in Baghdad, samples washed, dried, cutting, burned, powdered and pressed by a hydrolec press into small pellets(2cm^2 in diameter), and inserted between two pieces (1x1cm^2) of CR-39 as sandwich. The CR-39-sample-CR-39 sandwich then irradiated with fast neutrons have an energy more than (4.8MeV) emanated from (Am^{241}-Be) neutron source of (38mci) activity . This fast neutron irradiation causes uranium (^{238}U) to fission into minerals of interest, and some fission fragments are ejected into the track detector [6] according to the interaction [7]:

$$^{238}_{92}U + ^{1}_{0}n \text{ (fast)} \rightarrow ^{239}_{92}U^* \rightarrow \text{fissions}$$

After irradiation the detectors were isolated into two groups; both etched in 6.25 NaOH solution at 60º C, but one of them was synths using water bath and the other was synths by using microwave. The fission tracks produced in the etched detectors were then viewed under transmission optical microscope N-200M (400X magnification), pictured by camera then counted to estimate the best etching time for the detectors at each technique.

3. CALCULATIONS

3.1. Uranium concentrations

The uranium concentration in tissue samples determine by comparing its track density with the track density obtained from the standard of known concentration from the relation:

$$U_x / U_s = \rho_x / \rho_s \ldots\ldots\ldots(1)$$

Where

U_x is the uranium concentration in the sample.
U_s is the uranium concentration in the standard.
ρ_x is the density of the induced fission tracks of the sample.
ρ_s is the density of the induced fission tracks of the standard.

4. RESULTS AND DISCUSSION

4.1. Etching time estimation

Several irradiated CR-39 detectors have been chosen to estimate the appropriate etching time for the uranium fission fragments once when using water bath , other when using microwave device.

4.1.1 Chemical etching with water bath

30 mints would be the sufficient time to get clear and large number of tracks from the chosen etching time (25, 30,35,40,50 mints).That's after this time the tracks will begin to decrease gradually until then disappear. As shown in Fig (1) this time gave a good un agreement with khan [8]. And agreement with murtadha (9).

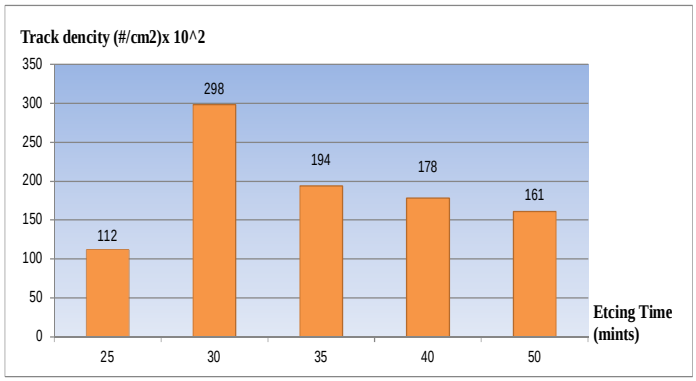


Figure1: Fission fragments track densities relative to etching time with water bath.

4.1.2. Chemical etching induced microwave technique

8 minutes would choose to be the appropriate time from 4 experimented times for developing the fission fragments tracks in CR-39 using chemical etching induced microwave .Etching time for tracks originate from uranium fission fragments was estimate for the first time in our research.

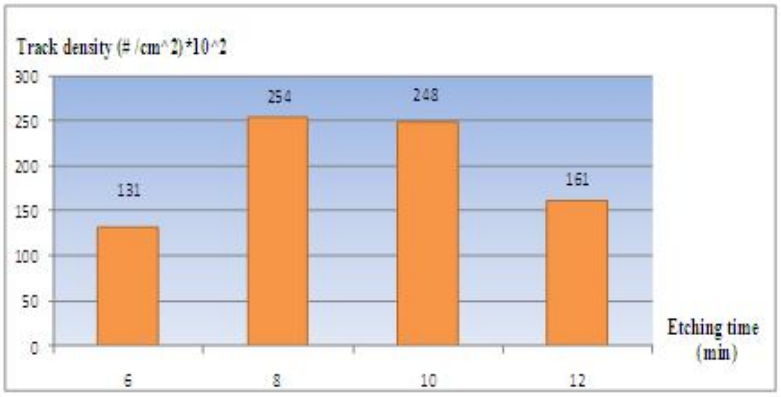


Figure2: Fission fragments track densities relative to etching time using microwave technique.

4.2. Evaluation of the uranium concentrations

Natural uranium concentrations in human tissues samples have been calculated from equation (1), the standard amounts of Us and ρs was taken from the reference [4].

4.2.1 Uranium concentrations calculated using CR-39 etched with water bath

The natural uranium concentrations have been measured in 50 samples of two different organs as shown in table 3. (25 uterus samples) and table 4.(25 breast samples) each table includes sample code, age of the patient ,track density and uranium concentration. for uterus samples as in table.3 the highest concentration was (**0.069**ppm) in U7 belong to the oldest examined women sample (57 year), while the lowest concentration was (**0.057**ppm) in U4 belong to women aged 45 year. And the mean average for all samples will be (**0.062**ppm).

Table 3: Natural uranium concentrations in uterus tissues samples measured by CR-39 etched chemically with water bath

Sample code	Age(year)	Track density ($\#/mm^2$ x10^2)	Uranium concentration(ppm)
U1	56	325	0.063
U2	50	305	0.059
U3	42	316	0.061
U4▼	**45**	**292**	**0.057**
U5	45	329	0.064
U6	51	329	0.064
U7 ▲	**57**	**354**	**0.069**
U8	40	337	0.065
U9	42	335	0.065
U10	52	329	0.064
U11	50	311	0.060
U12	50	347	0.068
U13	40	337	0.065
U14	52	339	0.066
U15	54	305	0.059
U16	47	310	0.060
U17	45	325	0.063
U18	44	340	0.066
U19	51	304	0.059
U20	52	307	0.060
U21	49	320	0.062
U22	46	325	0.063
U23	42	317	0.062
U24	47	323	0.063
U25	51	304	0.059
mean			0.062

For breast samples as in table.4 the highest concentration was (**0.065**ppm) in B10 belong to women aged 42 year, while the lowest concentration was (**0.057**ppm) in B6 belong to women aged 44year. And the mean average for all samples will be (**0.060**ppm).

Table 4:natural uranium concentrations in breast tissues samples measured by CR-39 etched with water bath

Sample code	Age(year)	Track density (#/mm^2 x10^2)	Uranium concentration(ppm)
B1	23	305	0.059
B2	58	300	0.058
B3	32	304	0.059
B4	51	311	0.060
B5	42	321	0.062
B6▼	**44**	**294**	**0.057**
B7	48	325	0.063
B8	45	321	0.062
B9	53	298	0.058
B10▲	**42**	**333**	**0.065**
B11	46	302	0.059
B12	29	298	0.058
B13	33	320	0.062
B14	45	315	0.061
B15	47	310	0.060
B16	40	306	0.059
B17	43	299	0.058
B18	48	307	0.060
B19	36	320	0.062
B20	44	310	0.060
B21	58	312	0.061
B22	61	308	0.060
B23	50	313	0.061
B24	46	319	0.062
B25	44	311	0.060
mean			0.060

4.2.2 Uranium concentrations calculated using CR-39 etched chemically induced microwave technique.

Natural uranium concentrations have been measured in the same previous samples using microwave technique instead of water bath as shown in tables 5. and 6. For uterus samples as in table.5 the highest concentration was (**0.056**ppm) in U5 belong to women aged 52 year, while the lowest concentration was (**0.038**ppm)in U7 belong to the youngest women. And the mean average for all samples will be (**0.047**ppm). For breast samples as in table.6 the highest concentration was (**0.041** ppm) in B5 belong to women aged 44 year, while the lowest concentration was (0.036ppm)in B4. And the mean average for all samples will be (**0.039** ppm).

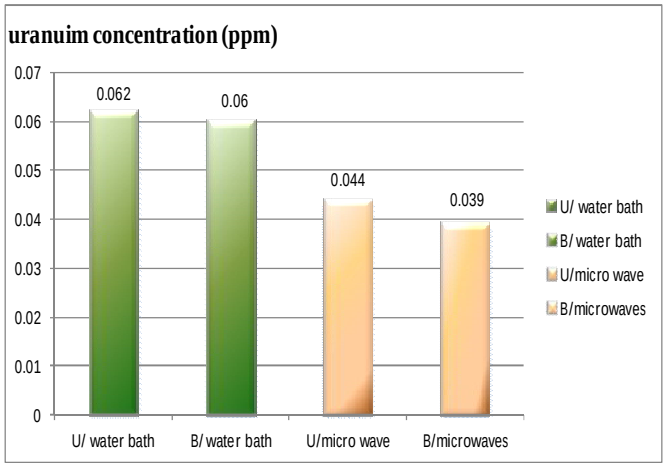
Table 5: Natural uranium concentrations in uterus tissues samples measured by CR-39 etched with microwave

Sample code	Age(year)	Track density (#/mm^2 x10^2)	Uranium concentration(ppm)
U1	40	230	0.045
U2	52	237	0.046
U3	51	212	0.041
U4	57	226	0.044
U5▲	**52**	**288**	**0.056**
U6	45	218	0.042
U7▼	**39**	**198**	**0.038**

U8	42	250	0.048
U9	35	241	0.047
U10	38	252	0.049
U11	44	237	0.046
U12	50	255	0.049
U13	35	257	0.050
U14	61	260	0.050
U15	34	266	0.052
U16	44	228	0.044
U17	42	240	0.046
U18	48	252	0.049
U19	40	230	0.045
U20	47	262	0.051
U21	41	255	0.049
U22	42	250	0.048
U23	58	240	0.046
U24	60	247	0.048
U25	47	243	0.047
Mean			0.047

Table 6: Natural uranium concentrations in breast tissues samples measured by CR-39 etched with microwave

Sample code	Age(year)	Track density (#/mm^2 x10^2)	Uranium concentration(ppm)
B1	23	200	0.039
B2	32	201	0.039
B3	51	209	0.040
B4▼	42	185	0.036
B5▲	44	214	0.041
B6	48	207	0.040
B7	42	209	0.040
B8	46	199	0.039
B9	53	209	0.040
B10	29	208	0.040
B11	53	195	0.039
B12	44	201	0.039
B13	40	196	0.038
B14	39	208	0.040
B15	56	207	0.040
B16	40	210	0.041
B17	32	198	0.038
B18	44	208	0.040
B19	56	200	0.039
B20	47	201	0.039
B21	39	191	0.037
B22	34	205	0.040
B23	55	203	0.039
B24	62	207	0.040
B25	50	209	0.040
mean			0.039



Figure(3): Track density of tissue samples [uterus(U)and breast(B)] relative to etching technique (water bath and microwave).

Table 7: difference between mean uranium concentration relative to the used etching technique (water bath and microwave)

Tissue type	Mean of natural uranium concentration (ppm)	
	Uterus	Breast
Water bath	0.062	0.060
microwave	0.047	0.039
Difference	0.015	0.021

5. CONCLUSIONS

From our research we can conclude the followings:

1. The etching time when using microwave is less than the etching time when using water bath by amount.
2. The track densities evaluated when using water bath is larger than the tracks densities when using microwave.
3. The optimum etching time for fission fragments in CR-39 is 30mints when using water bath.
4. The optimum etching time for fission fragments in CR-39 is 8 mints when using microwave.
5. The mean uranium concentrations in uterus when etching with water bath is (0.062ppm), and when etching with microwave is (0.047ppm). The difference between them is (0.015ppm). This value is high compared with the world values (0.001ppm) of human body [10].
6. The mean uranium concentrations in breast when etching with water bath is (0.060ppm), and when etching with microwave is (0.039 ppm). The difference between them is (0.021ppm) and this value is high compared with the world values (0.001ppm) of human tissues [10].

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