Journal of Wasit for Science and Medicine 2024: 17(2), 65-75

Measurement of The Radioactive Content and Dose of Water Samples (Tap and RO) For Children in Kut

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Abstract

The radiological quality of ^{238}U, ^{232}Th, and ^{40}K in drinking water samples (tap and RO planet water) collected in Kut, Iraq. Samples were measured using direct ray spectroscopy as reported in the current study. The mean activity concentrations of ^{238}U, ^{232}Th, and ^{40}K for tap and RO drinking water were (1.5-3.78), (0.81-2.52), (9.08-27.04), (1.41-3.32), (0.8-2.43) , and (9.15-24.44) Bq.L^{-1} respectively. Drinking water (tap and RO planet) is expected to contain ^{238}U, ^{232}Th, and ^{40}K at typical doses of (0.000049275-0.000124173), (0.000136-0.000423), (4.11E-05-1.22E-04), (4.63E-05-1.09E-04), and (0.000134-0.000408) individually.

Key words: Drinking water, radiation, effective dose, contamination.

1. Introduction

Water is vital to human life that it ranks as the second most important compound. Without water, life as we know cannot be lived. However, finding clean water for human consumption is extremely difficult as it is becoming a major global issue. Approximately half of the world's population is thought to be affected by freshwater contamination, which is a concern [1]. Drinking water is essential for human survival and social progress. Ensuring the health of a community is a top responsibility, and this includes providing clean water sources. One of the main factors influencing lower rates of death and illness as well as better economic development in underdeveloped nations is access to clean drinking water. As a result, drinking water use and its potential risks to human health have emerged as the main areas of interest for environmental researchers worldwide [2]. World Health Organization (WHO) estimates that at least 785 million people lack access to safe drinking water [3]. If everyone had access to basic sanitation facilities and practiced good hygiene, at least 2 million fatalities may have been prevented in due course [3]. Most radiation exposure that humans experience originates from natural sources, such as ingestion or absorption of radioactive materials, as well as external radiation sources including cosmic and terrestrial radiation. It is a common radioactive trace element that can be found in varying concentrations in practically all terrestrial compounds. Water is essential to the geophysical and geochemical processes that recycle trace elements into the biosphere throughout time. Finding naturally occurring radionuclides in water samples, such as Th and U, is also crucial [4]. The radioactive decay products from the three naturally occurring radioactive series on Earth (Uranium-238, Uranium-235, Thorium-232 series), as well as potassium-40. Those elements are the major reason of natural radionuclides present in water and food. In the Earth's crust, uranium is found in the biggest proportion as ^{238}U isotope, but thorium, with the highest naturally occurring isotopic abundance corresponding to the ^{232}Th isotope, is thought to be three times more plentiful [5].

2. Radionuclides in drinking water

2.1 Uranium (^{238}U)

Uranium is a lithophyte because it is strongly bound to oxygen and prefers to remain close to the surface of the earth. It naturally exists in minerals, rocks, soils, and water. It can also be acquired from a variety of artificial sources, such as mine waste, phosphate fertilizers, fly ash from power plants, and military uses [6]. Uranium that is found in the Earth gets transported to plants, water, food additives, and ultimately humans. High ionization power alpha radiation from uranium nuclides can be dangerous if breathed in or consumed in larger doses. Natural uranium may have harmful health effects because of its chemical and radioactive characteristics [4].

2.2 Thorium (^{232}Th)

Thorium is another radioactive element that exists in several isotope forms and belongs to the actinide series. Thorium can be found in most of the natural decay series (U-238, U-235, and Th-232). With atomic weights ranging from 209 to 238 there are 27 isotopes in total, including synthetic isotopes. The naturally occurring isotopes with the longest half-lives are Th-232, Th-230, Th-228, and Th-229, with half-lives of 1.4×10^{10} years, 7.7×10^{4} years, and 1.9 years, respectively. In contrast, the half-life of the purposefully created isotopes is 7.3×10^{3} years. The various activities of the natural thorium isotopes. Due to its short half-life, Th-234 is used in laboratory research [7].

2.3 Potassium (^{40}K)

Potassium is an important element for human health and is rarely present in drinking water at amounts that should worry healthy people [8]. Potassium can be found across the environment, including in all natural waters. As a result of potassium permanganate being used as an oxidant in water treatment, it can also appear in drinking water [8].

3. Hazard indices

3.1 Representative level index (Iγr)

Systematically determine if the sample complies with the dose criterion limitations. A different measure of radiation risk level index the method that utilised to determine the radiation risk, the radionuclides in the samples under examination posed is described as follows.

$$I_{\gamma} = \frac{A_U}{150} + \frac{A_{Th}}{100} + \frac{A_K}{1500} \quad (1)$$

For the radiation threat to be considered negligible, the representative level index (I_{γ}) needs to be less than unity [9].

3.2 External hazard index (H_{ex})

The external hazard index is a popular hazard metric that reflects external exposure. The following equation is how H_{ex} is defined (UNSCEAR, 2000)

$$H_{ex} = \frac{A_U}{370} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \quad (2)$$

Referring to uranium activity, thorium activity, and potassium activity of A_U, A_{Th}, and A_K are used [10].

3.3 Internal hazard index (H_{in})

H_{in} is a metaphor for the internal threat, by using the internal hazard index value and the definition of internal radiation exposure in respect to an internal danger in equation (3) [11].

$$H_{in} = \frac{A_U}{185} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \quad (3)$$

4. Materials and methods

4.1 Samples collection and preparation

Forty-four samples in total were collected from Al-Kut city in Wasit governorate. Samples were divided into two major groups. Twenty-two samples came from RO filtering stations while the other twenty-two samples were from tap water. Water samples were kept in polypropylene sealed containers, beside each sample volume was exactly five litres. Individual samples were heated to reduce the volume from five to one litre. Then, to prepare the radiological inspection using a sodium iodide detector, thallium restaurant. Samples were placed in one litre plastic containers.

4.2 Sample counting and detector efficiency calibration

Thallium-doped sodium iodide, or NaI(Tl), has a considerable volume of extremely high efficiency along with a high atomic number and reasonable density. The energy resolution is the most crucial component of detectors meant to measure the energy of incident radiation. The degree to which a detector can discern between two closely spaced energies is known as its energy resolution. Typically, the resolution (R) is expressed in terms of a peak's full width at half maximum (FWHM). In trials where huge detector volumes are required, several researchers find that even while semiconductor detectors offer a greater energy resolution, they cannot completely replace the NaI(Tl) [12]. Scintillation detectors are regarded as a basic radiation detector and are frequently employed in a variety of sectors, including environmental monitoring, industry, and health physics. Accurate detection efficiency knowledge is crucial for operating these systems, as it is influenced by various aspects including the peak-analysis technique, detector electronics, and source-detector geometry. The difference between the radiation recorded in the detector and the amount released by a radioactive source is largely dependent on the detection efficiency [13]. From measurements before, during, and after the experiments, it was discovered that the background levels in the laboratory were maintained constant throughout the entire period of measurements. The environmental ɤ-ray background at the laboratory site was determined using the same standard plastic container under identical measurement conditions.

4.3 Calculation of elemental concentration

The area of notable gamma-ray energy after background subtraction was used to compute the specific activity concentration (A_s) of the radionuclides ^{238}U, ^{232}Th, and ^{40}K in water using equation four.

$$A_S = \frac{CPS}{\varepsilon_\gamma \times I_\gamma \times V} \quad (4)$$

Where (A_s) is the specific activity in Bq/L, CPS is the net count rate under peak per second and the background under this peak of the experimental sample are subtracted, V is the volume of the sample and is the absolute efficiency for each gamma-ray energy. The probability of gamma ray emission at each respective -ray energy is given by the symbol $E_ɤ$, $I_ɤ$ [14].

Table1: The concentration of radiological elements (^{283}U, ^{232}Th and ^{40}K) in tap and RO planets drinking water in Kut city- Iraq.

Samples	^{238}U(Bq/L)	^{232}Th(Bq/L)	^{40}k(Bq/L)	Samples	^{238}U(Bq/L)	^{232}Th(Bq/L)	^{40}k(Bq/L)
WHO	3	0.6	-	WHO	3	0.6	-
W1	1.41	0.81	10.29	T1	1.5	1.1	19.54
W2	2.64	1.97	30.36	T2	1.58	0.93	15.13
W3	2.53	1.14	18.35	T3	3.45	1.33	27.04
W4	1.84	1.8	16.38	T4	2.09	1.21	15.67
W5	2.43	1.62	13.73	T5	2.13	1.21	18.26
W6	2.16	1.28	21.13	T6	2.36	1.64	20.14
W7	1.74	1.22	14.83	T7	2.21	1.26	12.89
W8	2.2	1.64	15.22	T8	2.68	1.39	16.91
W9	2.71	0.93	10.65	T9	1.97	1.29	21.63
W10	2.12	1.17	11.72	T10	2.48	0.91	14.46
W11	1.89	1.3	14.93	T11	2.38	1.26	22.52
W12	2.95	1.65	24.44	T12	2.45	0.81	9.07
W13	2.27	0.8	9.15	T13	3.22	1.08	12.03
W14	2.52	1.35	17.63	T14	2.87	1.42	15.61
W15	2.17	1.58	22.4	T15	2.06	1.44	17.39
W16	2.03	1.64	17.46	T16	2.49	1.43	14.34
W17	2.29	1.62	18.81	T17	3.78	1.67	21.66
W18	3.02	1.12	11.5	T18	2.44	1.02	9.44
W19	2.11	1.5	15.28	T19	2.52	0.95	9.08
W20	2.32	1.06	11.45	T20	3.4	1.06	17.69
W21	3.32	2.43	22.64	T21	3.38	1.71	17.44
W22	2.98	1.68	21.62	T22	2.49	2.52	22.55

5. Results and Discussion

5.1 Calculation of effective dose

The International Commission on Radiological Protection (ICRP) created the effective dose (E), a radiological protection number that may be used to compare dose limitations for stochastic effects and to put the optimization principle into practice (ICRP, 2007).

With the intention of give a mechanism for evaluating the radiation harm from partial body irradiations in terms of data acquired from whole body irradiations, the notion of "effective dose" was proposed in 1975. The effective dose is the mean absorbed dose from a uniform whole-body irradiation that causes the same overall radiation damage as the in-question no uniform, partial-body irradiation [12]. The yearly effective dose was estimated using the intake of specific radionuclides and ingestion doses coefficients ($SvBq^{-1}$) given by the International Commission on Radiological Protection under the assumption that the volume of the daily intake of a drinking water for an adult male is $2Ld^{-1}$. The following equation can be used to get the annual effective dose per person.

$$AED = \sum_i I_i \times 365 \times D_i \quad (5)$$

Where I_i is the radionuclide's daily intake (in Bq), and D_i is the ingestion dose coefficient (in Sv, in Bq) [15]. Infant (under one year old): Infants who are nursed solely don't need any extra fluids. Because human milk contains 87 % water during the first six months of life, it can be used to predict the right amount of water to consume. A daily volume of human milk is equivalent to 680 mL of water consumed overall, or between 100 and 190 mL/kg per day at that time.

Table 2: The impact of a radioactive element yearly intake of tap water on infants under one year old.

Tap water				RO water			
sample code	D-Eff of ^{238}U (µSv/y)	D-Eff of ^{232}Th(µSv/y)	D-Eff of ^{40}K(µSv/y)	sample code	D-Eff of ^{238}U (µSv/y)	D-Eff of ^{232}Th(µSv/y)	D-Eff of ^{40}K(µSv/y)
WHO (2004)	0.000114975	0.000263	-	WHO (2004)	0.000114975	0.000263	-
UNSCEAR (2000)	3.8325E-08	2.19E-08	-	UNSCEAR (2000)	3.8325E-08	2.19E-08	-
T1	5.74875E-05	0.000482	0.000278	W1	5.40383E-05	0.000355	0.000146
T2	6.05535E-05	0.000407	0.000215	W2	0.000101178	0.000863	0.000432
T3	0.000132221	0.000583	0.000385	W3	9.69623E-05	0.000499	0.000261
T4	8.00993E-05	0.00053	0.000223	W4	0.000070518	0.000788	0.000233
T5	8.16323E-05	0.00053	0.00026	W5	9.31298E-05	0.00071	0.000195
T6	0.000090447	0.000718	0.000287	W6	0.000082782	0.000561	0.000301
T7	8.46983E-05	0.000552	0.000183	W7	6.66855E-05	0.000534	0.000211
T8	0.000102711	0.000609	0.000241	W8	0.000084315	0.000718	0.000217
T9	7.55003E-05	0.000565	0.000308	W9	0.000103861	0.000407	0.000152
T10	0.000095046	0.000399	0.000206	W10	0.000081249	0.000512	0.000167
T11	9.12135E-05	0.000552	0.000321	W11	7.24343E-05	0.000569	0.000213
T12	9.38963E-05	0.000355	0.000129	W12	0.000113059	0.000723	0.000348
T13	0.000123407	0.000473	0.000171	W13	8.69978E-05	0.00035	0.00013
T14	0.000109993	0.000622	0.000222	W14	0.000096579	0.000591	0.000251
T15	7.89495E-05	0.000631	0.000248	W15	8.31653E-05	0.000692	0.000319
T16	9.54293E-05	0.000626	0.000204	W16	7.77998E-05	0.000718	0.000249
T17	0.000144869	0.000731	0.000308	W17	8.77643E-05	0.00071	0.000268
T18	0.000093513	0.000447	0.000134	W18	0.000115742	0.000491	0.000164
T19	0.000096579	0.000416	0.000129	W19	8.08658E-05	0.000657	0.000218
T20	0.000130305	0.000464	0.000252	W20	0.000088914	0.000464	0.000163
T21	0.000129539	0.000749	0.000248	W21	0.000127239	0.001064	0.000322
T22	9.54293E-05	0.001104	0.000321	W22	0.000114209	0.000736	0.000308

Table 3: The impact of a radioactive element yearly intake of tap water on one year old infant.

Tap water				RO water			
sample code	Eff of U (µSv/y)	Eff of Th (µSv/y)	Eff of K-40 (µSv/y)	sample code	Eff of U (µSv/y)	Eff of Th (µSv/y)	Eff of K-40 (µSv/y)
WHO (2004)	0.0001314	9.86E-05	-	WHO (2004)	0.0001314	9.86E-05	-
UNSCEAR (2000)	4.38E-08	8.21E-09	-	UNSCEAR (2000)	4.38E-08	8.21E-09	-
T1	0.0000657	0.000181	0.0003	W1	0.000061758	0.000133	0.000158
T2	6.92E-05	0.000153	0.000232	W2	0.000115632	0.000324	0.000465
T3	0.0001511	0.000218	0.000415	W3	0.000110814	0.000187	0.000281
T4	9.154E-05	0.000199	0.00024	W4	0.000080592	0.000296	0.000251
T5	9.329E-05	0.000199	0.00028	W5	0.000106434	0.000266	0.00021
T6	0.0001034	0.000269	0.000309	W6	0.000094608	0.00021	0.000324
T7	9.68E-05	0.000207	0.000198	W7	0.000076212	0.0002	0.000227
T8	0.0001174	0.000228	0.000259	W8	0.00009636	0.000269	0.000233
T9	8.629E-05	0.000212	0.000332	W9	0.000118698	0.000153	0.000163
T10	0.0001086	0.000149	0.000222	W10	0.000092856	0.000192	0.00018
T11	0.0001042	0.000207	0.000345	W11	0.000082782	0.000214	0.000229
T12	0.0001073	0.000133	0.000139	W12	0.00012921	0.000271	0.000375
T13	0.000141	0.000177	0.000184	W13	0.000099426	0.000131	0.00014
T14	0.0001257	0.000233	0.000239	W14	0.000110376	0.000222	0.00027
T15	9.023E-05	0.000237	0.000267	W15	0.000095046	0.00026	0.000343
T16	0.0001091	0.000235	0.00022	W16	0.000088914	0.000269	0.000268
T17	0.0001656	0.000274	0.000332	W17	0.000100302	0.000266	0.000288
T18	0.0001069	0.000168	0.000145	W18	0.000132276	0.000184	0.000176
T19	0.0001104	0.000156	0.000139	W19	0.000092418	0.000246	0.000234
T20	0.0001489	0.000174	0.000271	W20	0.000101616	0.000174	0.000176
T21	0.000148	0.000281	0.000267	W21	0.000145416	0.000399	0.000347
T22	0.0001091	0.000414	0.000346	W22	0.000130524	0.000276	0.000331

For children in their first year of life, 100-190 mL/kg per day is estimated. For age between 6 and 12 months a total water consumption is estimated from 800 to1000 mL/day. children aged between 4 and 8 years old, total water consumption (food moisture plus drinks) estimated from 1300 mL/day or 56 mL/kg daily.

Table 4: The impact of a radioactive element yearly intake of tap water on 5 years old babies.

Tap water				RO water			
sample code	Eff of ^{238}U(μSv/y)	Eff of Th(μSv/y)	Eff of ^{40}K(μSv/y)	sample code	Eff of ^{238}U(μSv/y)	Eff of Th(μSv/y)	Eff of ^{40}K(μSv/y)
WHO (2004)	0.00015768	0.000138	-	WHO (2004)	0.00015768	0.000138	-
UNSCEAR (2000)	5.256E-08	1.15E-08	-	UNSCEAR (2000)	5.256E-08	1.15E-08	-
T1	0.00007884	0.000253	0.00027	W1	7.41096E-05	0.000186	0.000142
T2	8.30448E-05	0.000214	0.000209	W2	0.000138758	0.000453	0.000419
T3	0.000181332	0.000306	0.000373	W3	0.000132977	0.000262	0.000253
T4	0.00010985	0.000278	0.000216	W4	9.67104E-05	0.000414	0.000226
T5	0.000111953	0.000278	0.000252	W5	0.000127721	0.000373	0.000189
T6	0.000124042	0.000377	0.000278	W6	0.00011353	0.000294	0.000292
T7	0.000116158	0.00029	0.000178	W7	9.14544E-05	0.000281	0.000205
T8	0.000140861	0.00032	0.000233	W8	0.000115632	0.000377	0.00021
T9	0.000103543	0.000297	0.000298	W9	0.000142438	0.000214	0.000147
T10	0.000130349	0.000209	0.0002	W10	0.000111427	0.000269	0.000162
T11	0.000125093	0.00029	0.000311	W11	9.93384E-05	0.000299	0.000206
T12	0.000128772	0.000186	0.000125	W12	0.000155052	0.000379	0.000337
T13	0.000169243	0.000248	0.000166	W13	0.000119311	0.000184	0.000126
T14	0.000150847	0.000327	0.000215	W14	0.000132451	0.00031	0.000243
T15	0.000108274	0.000331	0.00024	W15	0.000114055	0.000363	0.000309
T16	0.000130874	0.000329	0.000198	W16	0.000106697	0.000377	0.000241
T17	0.000198677	0.000384	0.000299	W17	0.000120362	0.000373	0.00026
T18	0.000128246	0.000235	0.00013	W18	0.000158731	0.000258	0.000159
T19	0.000132451	0.000218	0.000125	W19	0.000110902	0.000345	0.000211
T20	0.000178704	0.000244	0.000244	W20	0.000121939	0.000244	0.000158
T21	0.000177653	0.000393	0.000241	W21	0.000174499	0.000559	0.000312
T22	0.000130874	0.000579	0.000311	W22	0.000156629	0.000386	0.000298

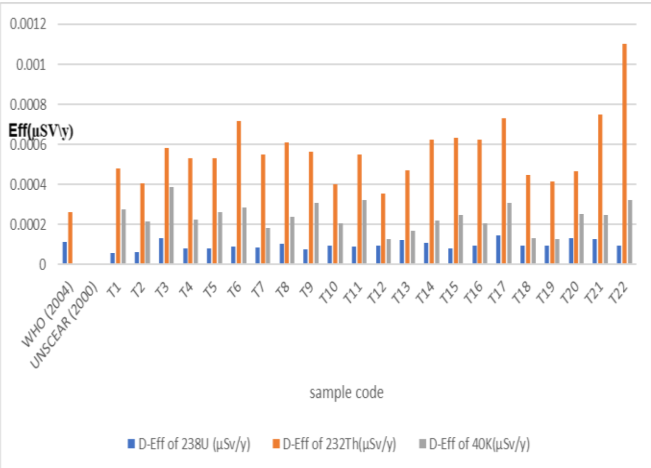

Figure 1: Effective dose of radioactive elements in tap water on infant younger than one year old.

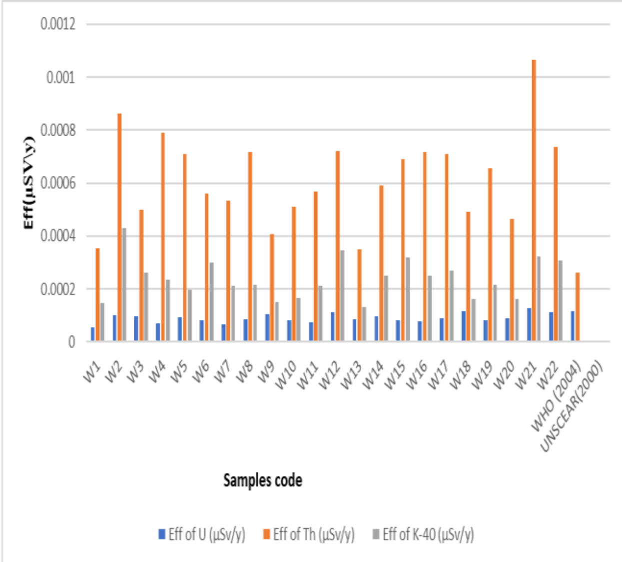

Figure 2: Effective dose of radioactive elements in RO planet on infants younger than one year old.

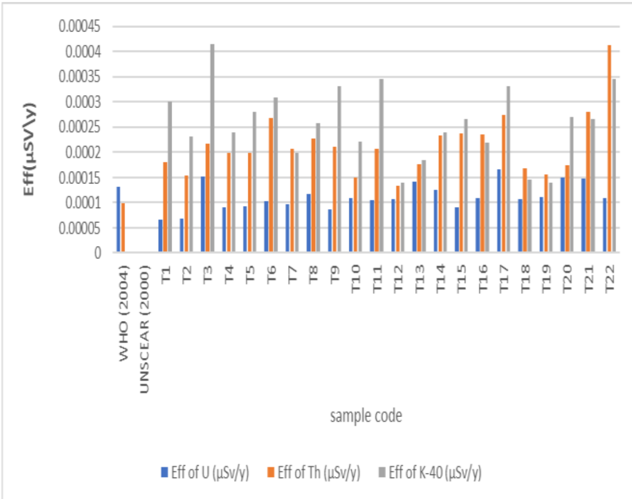

Figure 3: Effective dose of radioactive elements in tap water on infants aged one year old.

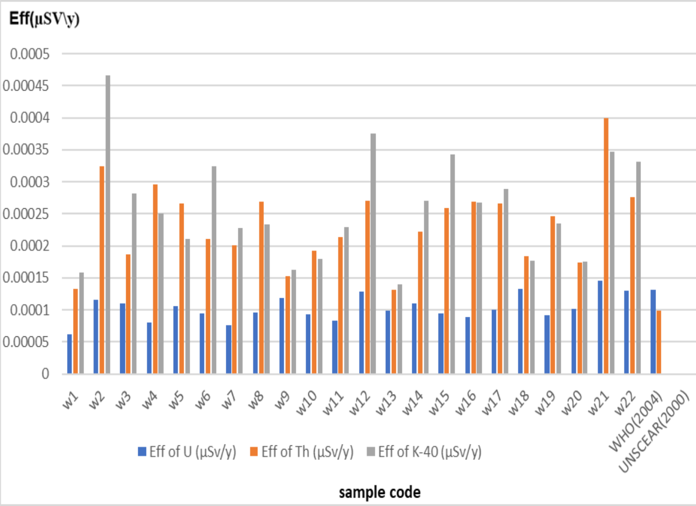

Figure 4: Effective dose of radioactive elements in the water of RO filtering stations on infants aged one year old.

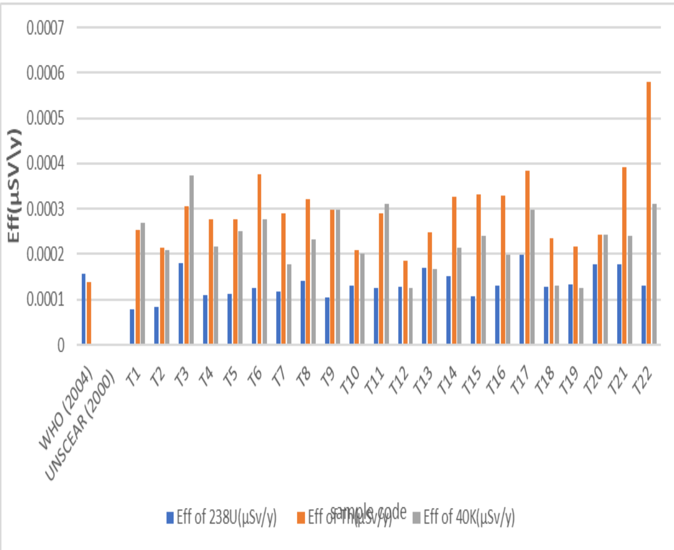

Figure 5: Effective dose of radioactive elements in tap water on children aged 5 years old.

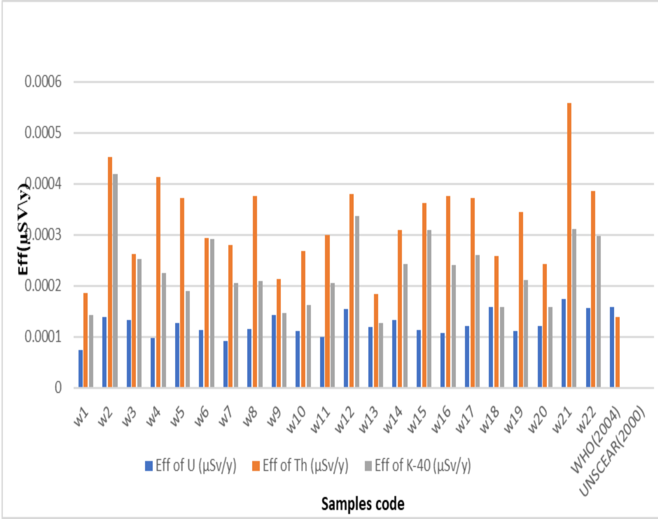

Figure 6: Effective dose of radioactive elements in RO planet water on children aged 5 years old.

6. Discussion

Results from (tables 1-4), and (figures 1-6) most of the study regions had significant concentrations of the element thorium, which is extremely dangerous for children if present in the water at high levels. Even though children drink less water daily than adults do. The outcome discovered that even modest amounts of thorium-^{232}Th contaminated water can have a significant negative impact on children's health and increase their vulnerability to future dangers. According to a recent study, there is a higher likelihood of congenital anomalies in infants and children living close to an active U.S. military base in Iraq due to their higher thorium (^{232}Th) exposure. These anomalies include neural tube defects (NTDs) and congenital heart diseases. Consequently, the harmful impact of maternal thorium (^{232}Th) exposure on birth abnormalities has drawn much public interest. Potassium ^{40}k is essential for growth and good health. High potassium levels were found in drinking water through data tables and graphs, which is not an ideal for children's health because high dose of potassium ^{40}k can affect child's normal process of growing teeth and bones. While low potassium is thought to be unhealthy. Due to the low concentration in water, uranium ^{238}U does not present any dangers, unlike thorium and potassium. It was within the tolerable range advised by the World Health Organization.

7. Conclusion

Samples first set of 22 samples were drawn from tap water, whereas the second set of 22 samples were drawn from RO planet water. After the test, the first group's uranium concentration ranged from (1.5-3.78) Becquerel per litre to (1.41-3.32) Becquerel per litre. For the second group, the concentration of the thorium element in the first group ranged from 0.81 to 2.52 Becquerel per litre, as well as 0.80 to 2.43 Becquerel per litre in the second group. The potassium concentration in the first group ranged from 9.07 to 27.04 Becquerel per litre, and from 9.15 to 30.36 Becquerel per litre in the second group. The calculated effective dose for each radioactive element for a range of age groups, starting with newborns and to seniors. Via applying ICRP tables, to 5 years. According to reported tables and graphs, the element thorium has the greatest influence on all age groups and geographical areas. Though to varying degrees depending on how much is present in each sample. Other two elements, uranium and potassium, had different effective dosages based on the concentration in each sample as well as the age groups.

8. References

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