Transfer of K^{40} from soil to plants in an agricultural field and its EDE from milk ingestion

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ABSTRACT

A large fraction of radiation exposure experienced by individuals through ingestion of food, is from natural occurring radionuclides such as K^{40}. In order to find the environmental radioactive background of K^{40} in Ninevah, Iraq, governorate and its transfer factor from soil to plant and then the effective dose equivalent from milk ingestion, the concentrations of K^{40} were measured in soil , plant and milk collected from 41 agricultural fields in Ninevah governorate in May/ June 2001. The employed counting system consisted of a 79cc HPGe detector coupled to 4096 channel type (CANBERRA). The photo peak was obtained for the particular counting geometry using standard calibration sources. Gamma spectrometric analysis of all samples indicated the presence of K^{40} which ranged between 323.86 and 1025 Bq/kg in soil samples and between 210.51 and 599.13 Bq/kg in plant and, finally 200.3 to 480.1 Bq/kg in milk samples. The transfer factor ranged between 0.439 and 0.943. It's variation was dependent on soil type, plant type and other environmental conditions. An empirical equation for estimating the transfer factor has been obtained and can be used in the absence of local field measurements. The Effective Dose Equivalent (EDE) from intake of K^{40} ranged between 34.1 and 81.6 µsv/y, which falls within the national permissible limit for milk ingestion.

Key words:

معامل انتقال البوتاسيوم K^{40} من التربة إلى النبات في المزارع الحقلية والجرعة المؤثرة المكافئة من تناول الحليب

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الملخص

يتعرض الأشخاص لجزء كبير من الأشعة المؤينة خلال تناول الغذاء الحاوي على العناصر المشعة الطبيعية مثل البوتاسيوم المشع K^{40}. ولإيجاد الخلفية الإشعاعية الطبيعية في محافظة نينوى من البوتاسيوم المشع K^{40} ومعامل انتقاله من التربة إلى النبات، ومن ثم الجرعة المؤثرة المكافئة من تناول الحليب الحاوي عليه, قيس البوتاسيوم المشع K^{40} في عينات التربة والنبات والحليب والتي جمعت من 41 موقعاً في عموم محافظة نينوى، (شمال الأنبار) ومن المزارع الحقلية خلال شهري الحصاد الخامس والسادس لسنة2001. تضمنت منظومة القياس عداد الجرمانيوم عالي النقاوة ببلورة حجم 79cc ومحللاً متعدد القنوات ذا 4096 قناة نوع CANBERRA . وتم تحديد موقع القمة الطاقية للبوتاسيوم المشع K^{40} باستخدام عددٍ من العناصر المشعة القياسية. أشار التحليل الطيفي لكل العينات إلى وجود عنصر البوتاسيوم المشع K^{40} بتراكيز تراوحت بين 1025 و323.86 Bq/kg في عينات التربة، وبين 599.13 و210.51 Bq/kg في عينات النبات، وأخيراً كانت نشاطية البوتاسيوم المشع K^{40} في عينات الحليب تتراوح بين 480.1 و200.3 Bq/kg. أما معامل الانتقال فقد تراوح بين0.439 و 0.943. يتوقف تركيز البوتاسيوم المشع على نوع التربة ونوع النبات والظروف البيئية والجغرافية والجيولوجية المحيطة. فقد تم إيجاد معادلة تجريبية لتخمين معامل الانتقال في حالة غياب القيم العملية الموقعية.كما تم إيجاد الجرعة المؤثرة المكافئة من دخول عنصر البوتاسيوم المشعK^{40} نتيجة تناول الحليب وكانت قيمه تقع ضمن القيم المسموح بها عالمياً إذ تراوحت بين 81.6 و34.1 µsv/y .

الكلمات المفتاحية:

Introduction

Metal elements are abundant in nature. They are found in soil, water, food, and in animal and plant tissues. Besides, there is a competition among these elements concerning their absorption. The increase in some metal elements decreases the absorption of others elements (Al-Kathy,1994; Hamid *et al*., 2000).

Potassium is considered one of the main metal elements in nature. It is widely spread in the earth’s crust. The radioactive isotope of potassium is K^{40}, having a half-life of 1.28 x 10^9 years. It forms 0.012% of the total natural potassium (Wright,1965; Hamad,1999), (Shinber,1999). The existence of potassium in nutrients differs according to the type of nutrient and potassium is readily absorbed in the intestines. Milk is considered one of the main nutrient materials and it's high nutrition value is due to its contents of main metal elements.

The percentage of potassium in milk is estimated to be 0.14% (Al-Ahmad, 1993). It may differ in different types of the same nutrient. It was observed that potassium in Japanese rice is higher than in Persian rice as well as there is difference in concentration among types of milk (Tsukada and Hasegawa, 2000). Concentrations of calcium and potassium elements are remarkably higher than most other elements in all types of Iraqi diet. There are many data reported about the natural radioactivity of some environmental samples in Iraq, (Al-Basam, 1979; Saed, 1980; Al- Ameri, 1982; and Hussain, 1999), as well as in other parts of the world.

Mokwar (1998) showed the possibility to assume that a linear relation exists between the concentration of a radioactive element in the plant and its concentration in soil, in similar environment al conditions. However, studies showed that transportation of radioactive material from soil to plant doesn’t take place in identical environmental conditions. On the other hand, the phenomenon of saturation indicates that transfer factor (TF) doesn’t follow a linear relationship IAEA (1994).

Finally, the type of nutrient, it's components and method of production in addition to the geological nature of the production location and climate are all basic elements in studying the environmental pollution and ways of transportation of pollutants to the human being whose well-being is our main objective.

The present study focused on the measurement of natural radioactive K^{40} in soil, plant and milk samples, collected from Ninevah governorate of Iraq. It's transfer factor was deduced and then the effective dose equivalent (EDE) from milk ingestion was calculated.

Experimental

1- Collecting samples:

After acquiring the topographic maps and the measurement of wind speed and direction in Ninevah governorate, soil, plant and milk samples were collected according to the dates of harvest of wheat and barley fields. Besides, stubble is considered an important source of animal food because of its high nutrient values and large number of grazing animals UNSC(1988).

After selecting sample sites (Fig.1), the soil samples collection was based on the recommendations of the International Atomic Energy Agency (IAEA,1994). For accuracy, a set of not less than 10 samples was collected from each site with an area not less than 10 m^2 and from four corners of each site. The depth ranged between 0-15cm. Each set of samples was mixed and dried under the sun for at least 4-5 days. Sample impurities and strange bodies were eliminated using a 2mm mesh sieve and the samples were put in plastic containers. Plant samples were taken from the same sites of the soil samples and the plant samples were cut from a low height (2mm) above ground which represents the height of the grass usually consumed by animals (Marouf, *et al.,* 1992). The plant samples were dried completely, impurities and strange bodies were removed and the samples were crushed, mechanically, to a fine grain and meshed through a 2mm sieve to be ready for laboratory examination. Finally, milk samples from animals in the same locations of soil and plants, were taken.

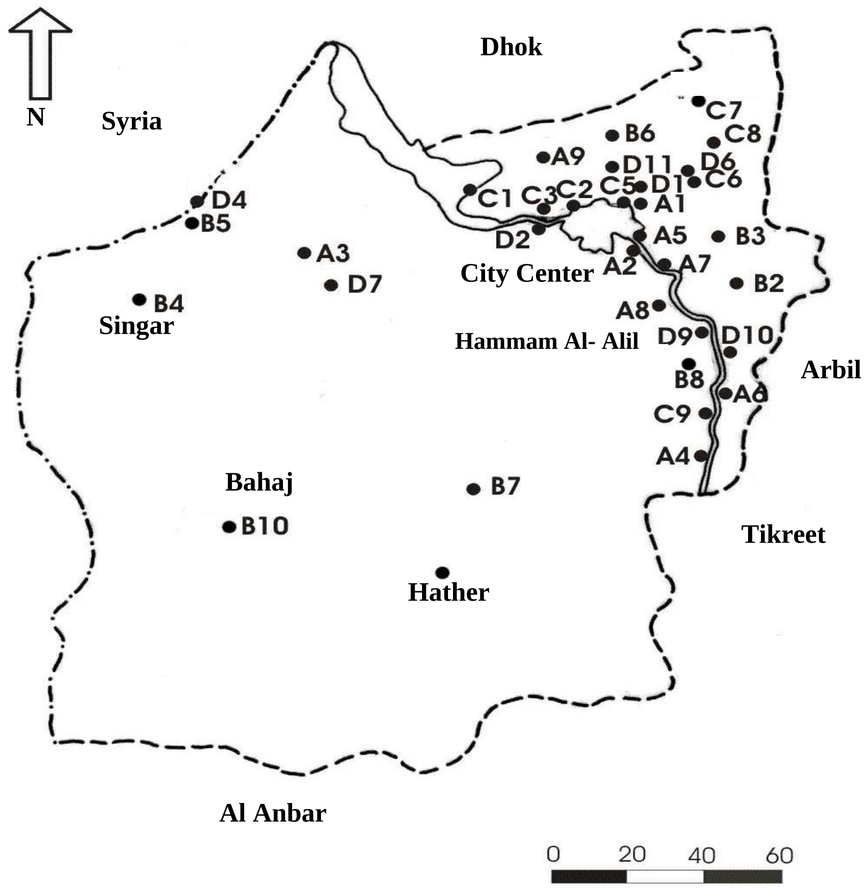

Fig (1) Selected sites for gathering samples in Ninaveh governorate.

2- Samples analysis:

To study the potassium K^{40} content in the samples, the High Purity Germanium Detector was used in addition to the multi-channel analyzer (Canberra 85).This procedure includes important steps especially for calibrating the energy and determining the peaks of the elements under investigation according to the area under the peak to find the activity of the radioactive element. The measurement system was arranged as in Fig (2).

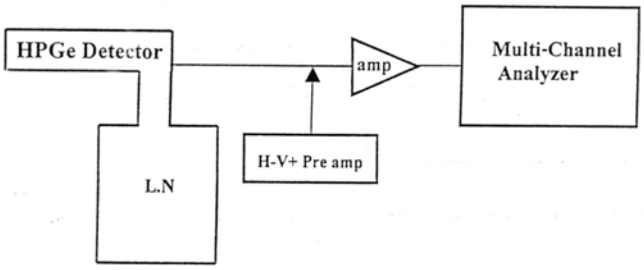

Fig (2) Germanium Counter System

The calibration was based on a set of reference radioactive sources of precisely defined energy and strength. The reference set was acquired from the (IAEA, 1982).

The best energy resolution for the 1332 keV peak of Co^{60} was 2.1 keV, and the differential and integral time constant of the operational amplifier was determined to be 3 msec.

Calculations

After preparing the detector and calculating the area under the peak for K^{40} and from the efficiency curve the specific activity C_p was determined using the formula (AL-Barode,2004).

$A = \text{area} / \varepsilon\% \times I\gamma \times t$……………………..(1)

C_P (Bq/kg) = A/W...................................(2)

Where

A: Sample activity

ε%: Efficiency

I_γ : Gamma intensity

t: Time of measurement

W: Weight of sample

Fig (3) shows the spectrum of one of the samples used in the current work.

Results and discussion

Specific activity of potassium K^{40} in soil, plant and milk

1- Specific activity of potassium K^{40} in soil:

Table (1) shows the specific activity of potassium K^{40} in soil and it is shown that there are high activity in the sites A2, A5, A7, B1, B2, B4, B5, B9, B10, C4, C6, C7, C8, D1, D4, D7, D11. The highest value recorded was 1025 Bq/kg at the site B4, which is considered a clay type soil rich in potassium. However, the locations A6, B8, C1, C3, D5, D10 showed relatively lower values when compared with the first group and the least value of 323.86 Bq/kg was recorded in the site C1, which is considered appropriate for field cultivating. The differences are due to the geological and geographical nature of the region.

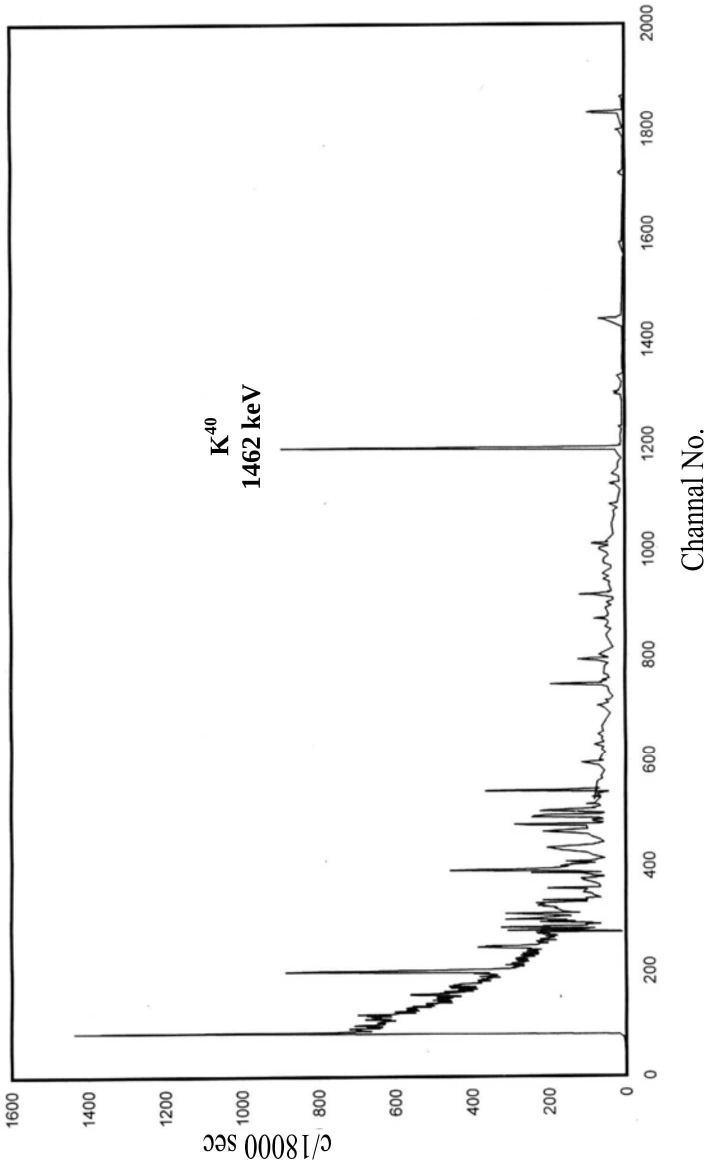

Fig (3) Spectrum of one sample used in the current work

Table(1) Specific activity and the weight of potassium K^{40} and percentage of potassium K in soil.

No.	Sample	Location	Area	Bq/kg	±Error	W(K^{40}) ppm	W K % g/g
1.	A1	Bahweza	2325	627.5	13.0	2.43	2.02
2.	A2	Al-Bosef	12890	780	6.8	2.97	2.48
3.	A3	Owenat	2443	659.325	13.3	2.55	2.13
4.	A4	Al-Zewania	2224	600.22	12.7	2.30	1.94
5.	A5	Earmga	2828	763.23	14.3	2.95	2.46
6.	A6	Al-Namrod	1419	383	10.1	1.46	1.21
7.	A7	Al-Shamciat	2998	809.11	14.7	3.13	2.61
8.	A8	Kaber Al-Abd	2204	594.82	12.6	2.30	1.92
9.	A9	Felfel	2054	554.30	12.2	2.14	1.79
10.	A10	Al-Koba (near R22)	1359	566.76	15.3	0.96	0.80
11.	B1	Al-Sada	3330	898.70	15.5	3.48	2.90
12.	B2	Al-Hamdania	3600	971.58	16.1	3.76	3.13
13.	B3	Baltla	2313	624.24	12.9	2.41	2.01
14.	B4	SnJar	3800	1025.55	15.3	3.94	3.28
15.	B5	Rbeha	3500	944.59	15.9	3.60	3.00
16.	B6	Al-Kaosh	2229	601.69	12.7	2.29	1.913
17.	B7	Al-Ramzania	1880	507.38	11.7	1.93	1.61
18.	B8	Hamam Al- Alel	1440	388.63	10.2	1.48	1.23
19.	B9	Baathra (near R27)	2800	755.67	14.2	2.88	2.40
20.	B10	Al-Bahj	3300	890.62	15.5	3.39	2.83
21.	C1	Dam of Mousl	1200	323.86	9.3	1.23	1.03
22.	C2	Al Rashidia	2330	628.82	13.0	2.39	1.99
23.	C3	Near Al-Kindi Establishment	1370	369.74	9.9	1.41	1.17
24.	C4	Al- Noran(R25)	2760	744.87	14.1	2.84	2.36
25.	C5	Al-Salalat	1980	534.37	12.0	2.03	1.69
26.	C6	Bashiqa	2940	793.45	14.6	3.02	2.52
27.	C7	Ien Sfny	3370	909.51	15.6	3.47	2.89
28.	C8	Dear Maty(R27)	3540	955.38	16.0	3.64	3.03
29.	C9	AL-Shora	1741	470	11.2	1.79	1.49
30.	C10	Shersaka(R41)	2750	742.18	14.1	2.83	2.35
31.	D1	Hor Sabad	3170	855.53	15.1	3.26	2.72
32.	D2	Badosh	1540	415.62	10.5	1.58	1.32
33.	D3	Sherihan(R22)	2125	573.50	12.4	2.18	1.82
34.	D4	Tal koj	3250	877.12	15.3	3.34	2.78
35.	D5	Al Salahia(R18)	1465	395.38	10.3	1.50	1.25
36.	D6	The bridge of Mandan	1987	536.26	12.0	2.04	1.70
37.	D7	Tal Afar	3760	1014.76	16.5	3.87	3.22
38.	D8	Al- Kinde	1750	472.29	11.2	1.80	1.50
39.	D9	Al-Arig	2556	690.49	13.6	2.63	2.19
40.	D10	Al- Salamia	1405	379.18	10.1	1.44	1.20
41.	D11	Talkif	3740	1009.36	16.5	3.85	3.20

The average value for all the sites is 669.23 Bq/kg and can be adopted as the background for natural radiation activity in Ninevah governorate.

It is worth noting that the background for natural radiation activity of potassium K^{40} recorded in Basrah governorate was 475Bq/kg (Habbobi, 1986).

A number of international studies concerned with the specific activity of potassium K^{40} exist, and are considered as a radiation activity background for these countries. Fig (4) represents a comparison of the results obtained in this study with the international values published in the relative international studies.

It is apparent that the difference in the levels of radiation activity is due to the differences in the geological and geographical nature of these regions.

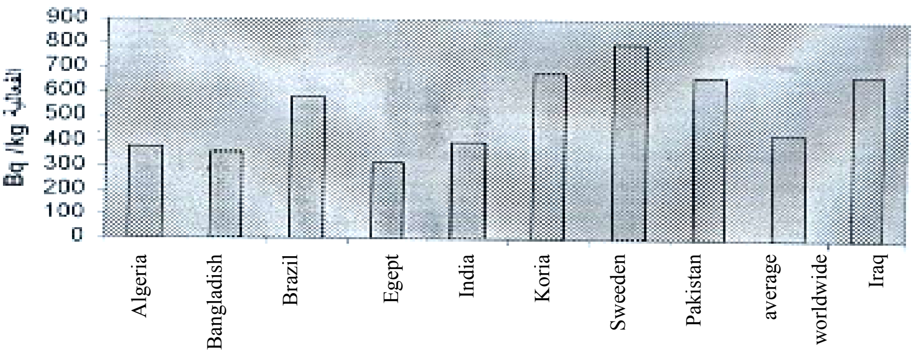

Fig (4) Comparison of the results obtained from this study with previous results for the specific activity of potassium k^{40}

Specific activity of potassium in soil ranged between 20%-60% of the total specific activity and may differ with the soil type and petrogenesis of the rocks that soil originated from. Rutherford (2002) stated that the concentration of Potassium K^{40} ranges between 0.3-4ppm while the concentration of stable Potassium K ranges between 0.013g/g-0.328g/g, these results coincide with those of Khider (2003) for Iraq (0.016-0.019g/g).

2- Specific activity of potassium K^{40} in plant:

Table (2) represents the values of specific activity of Potassium K^{40} in plants.

Table (2) Specific activity and the weight of potassium K^{40} and percentage of potassium K in plant.

No.	Sample	Location	Area	Bq/kg	± Eror	W(K^{40}) ppm	W K% g/g
1.	A1	Bahweza	1141	307.93	9.1	1.18	0.98
2.	A2	Al-Bosef	1945	525.99	11.9	2.00	1.66
3.	A3	Owenat	1587	428.30	10.7	1.66	1.38
4.	A4	Al-Zewania	2098	566.21	12.3	2.19	1.82
5.	A5	Earmga	1765	476.34	11.3	1.84	1.53
6.	A6	Al-Namrod	1046	282.50	8.7	1.07	0.89
7.	A7	Al-Shamciat	1444	389.54	9.2	1.50	1.25
8.	A8	Kaber Al-Abd	1246	336.27	9.5	1.30	1.08
9.	A9	Felfel	1501	405.10	10.4	1.54	1.28
10.	A10	Al-Koba (near R22)	945	455.29	14.8	0.97	0.81
11.	B1	Al-Sada	1777	479.50	11.3	1.85	1.54
12.	B2	Al-Hamdania	2011	542.73	12.1	2.10	1.75
13.	B3	Baltla	1212	327.09	9.3	1.26	1.05
14.	B4	SnJar	2220	599.13	12.7	2.28	1.90
15.	B5	Rbeha	1900	512.77	11.7	1.95	1.63
16.	B6	Al-Kaosh	1300	350.84	9.7	1.34	1.11
17.	B7	Al-Ramzania	1390	375.27	10.0	1.43	1.19
18.	B8	Hamam Al- Alel	850	229.39	7.8	0.87	0.72
19.	B9	Baathra (near R27)	1232	332.49	9.4	1.26	1.05
20.	B10	Al-Bahj	1540	415.61	10.5	1.58	1.32
21.	C1	Dam of Mousl	780	210.51	7.5	0.80	0.66
22.	C2	Al Rashidia	1250	337.35	9.5	1.28	1.07
23.	C3	Near Al-Kindi Establishment	875	236.14	7.9	0.90	0.75
24.	C4	Al- Noran(R25)	1760	474.98	11.3	1.81	1.51
25.	C5	Al-Salalat	1112	300.11	8.9	1.14	0.95
26.	C6	Bashiqa	1776	479.30	11.3	1.82	1.52
27.	C7	Ien Sfny	1950	526.26	11.9	1.37	1.15
28.	C8	Dear Maty(R27)	2116	571.06	12.4	2.17	1.81
29.	C9	AL-Shora	1260	340.19	9.5	1.29	1.08
30.	C10	Shersaka(R41)	1550	416.31	10.5	1.59	1.33
31.	D1	Hor Sabad	1625	438.55	10.8	1.67	1.39
32.	D2	Badosh	1012	273.11	8.5	1.04	0.86
33.	D3	Sherihan(R22)	1040	280.67	8.7	1.07	0.89
34.	D4	Tal koj	1780	480.38	11.3	1.83	1.52
35.	D5	Al Salahia(R18)	1026	357.88	11.1	1.36	1.13
36.	D6	The bridge of Mandan	1022	275.81	8.6	1.05	0.87
37.	D7	Tal Afar	1992	537.60	12.0	2.05	1.70
38.	D8	Al- Kinde	978	263.94	8.4	1.00	0.83
39.	D9	Al-Arig	1556	419.93	10.6	1.60	1.33
40.	D10	Al- Salamia	975	263.13	8.4	1.00	0.84
41.	D11	Talkif	2212	596.97	12.6	1.56	1.30

The highest value of Specific activity of Potassium K^{40} in plant ranged from the maximum value of 599.13 Bq/kg at site B4 and the minimum value of 210.51 Bq/kg in site C1 and the average of all values of collected samples reached 400.5 Bq/kg. The concentration of stable Potassium K in plant ranged between maximum value of 0.019 g/g at site B4 and the minimum value of 0.0066 g/g in site C1 and the average of all samples was 0.0123 g/g . Which seem reasonable when compared with values recorded in a number of nutrients as shown in Table (3) Al-Zohairy(1994)

Table (3) Potassium K content in a number of foods

Type of food	Potassium K content g/g
Carrots	0.013
Peach	0.009
Date	0.006
Raisin	0.008
Apple	0.005
Cereal	0.011
Banana	0.003

3- Specific activity of potassium K^{40} in milk:

Table (4) shows that the Specific activity of Potassium K^{40} in milk ranging between the maximum value of 480.1 Bq/kg at site D7 and the minimum value of 200.3 Bq/kg in site C1 and the average of all values of collected samples reached 339.7 Bq/kg. The transportation from plant to milk is clearly obvious as the element of potassium K is one of the main elements of milk composition Al-Zohairy (1994).

It is obvious that the activity of Potassium K^{40} in milk is close to the value stated by the researchers, Shinber (1991) in Libya, 320 Bq/kg and Al-Kathy (1994) 260 Bq/kg.

Comparison of the values of specific activity of Potassium K^{40} for each of the soil, plant and milk at the same sample sites. Showed that the sites rich in Potassium K^{40}, in the soil correspond to the sites of plant rich in Potassium K^{40} also in the same sites A2, A5, B2, B4, B5, C7, C8, D7, D11. The transportation of Potassium K^{40} from soil to plants depends on a number of factors related to the nature of the plant and cultivation conditions in addition to the climate effects of waterfall, temperature and wind. But the most important factor is the soil content of basic metal elements and the amount of these elements needed by the plant.

Table (4) Specific activity and the weight of potassium K^{40} and percentage of potassium K in milk.

No.	Sample	Location	Area	Bq/kg	± Eror	W(K^{40}) ppm	W K% g/g
1.	A1	Bahweza	921	248.5	8.1	0.94	0.79
2.	A2	Al-Bosef	1528	412.38	10.5	1.59	1.33
3.	A3	Owenat	1303	351.78	9.7	1.34	1.11
4.	A4	Al-Zewania	1488	401.5	10.4	1.55	1.29
5.	A5	Earmga	1724	465.27	11.2	1.8	1.5
6.	A6	Al-Namrod	926	250.8	8.2	0.95	0.79
7.	A7	Al-Shamciat	1313	354.35	9.7	1.37	1.14
8.	A8	Kaber Al-Abd	1141	307.93	9.1	1.19	0.99
9.	A9	Felfel	1128	304.55	9.0	1.16	0.96
10.	A10	Al-Koba (near R22)	1480	400.17	10.4	1.52	1.27
11.	B1	Al-Sada	1622	437.75	10.8	1.69	1.41
12.	B2	Al-Hamdania	1747	471.48	11.2	1.82	1.52
13.	B3	Baltla	1128	304.42	9.0	1.17	0.98
14.	B4	SnJar	1556	420	10.6	1.60	1.33
15.	B5	Rbeha	1157	312.25	9.1	1.19	0.99
16.	B6	Al-Kaosh	1038	280.13	8.6	1.06	0.89
17.	B7	Al-Ramzania	964	260.16	8.3	0.99	0.82
18.	B8	Hamam Al- Alel	749	202.14	7.3	0.77	0.64
19.	B9	Baathra (near R27)	1019	275.0	8.6	1.05	0.87
20.	B10	Al-Bahj	1410	380.53	10.1	1.45	1.21
21.	C1	Dam of Mousl	742	200.25	7.3	0.76	0.63
22.	C2	Al Rashidia	1131	305.23	9.0	1.16	0.97
23.	C3	Near Al-Kindi Establishment	797	215.09	7.6	0.82	0.68
24.	C4	Al- Noran(R25)	1483	400.23	10.3	1.52	1.27
25.	C5	Al-Salalat	927	250.17	8.2	0.95	0.79
26.	C6	Bashiqa	1527	412.11	10.5	1.57	1.31
27.	C7	Ien Sfny	1668	450.16	11.0	1.72	1.43
28.	C8	Dear Maty(R27)	1761	475.25	11.3	1.81	1.51
29.	C9	AL-Shora	1134	306.04	9.0	1.16	0.97
30.	C10	Shersaka(R41)	1412	381.07	10.1	1.45	1.21
31.	D1	Hor Sabad	1389	374.86	10.1	1.43	1.19
32.	D2	Badosh	755	203.75	7.4	0.77	0.64
33.	D3	Sherihan(R22)	788	212.66	7.5	0.81	0.67
34.	D4	Tal koj	1510	407.52	10.4	1.55	1.29
35.	D5	Al Salahia(R18)	1157	312.25	9.1	1.19	0.99
36.	D6	The bridge of Mandan	775	209.15	7.5	0.79	0.66
37.	D7	Tal Afar	1779	480.11	11.3	1.83	0.69
38.	D8	Al- Kinde	1333	359.75	9.8	1.37	1.14
39.	D9	Al-Arig	1483	400.23	10.3	1.52	1.27
40.	D10	Al-Salamia	1038	280.13	8.6	1.06	0.89
41.	D11	Talkif	1668	450.15	11.0	1.71	1.43

It has been observed that the average value of the specific activity of Potassium K^{40} in soil is higher than it's value in plant and milk by a factor 1.7 and 2.0 respectively. Potassium K^{40}, takes the same course in animal tissues as Potassium K which concentrates in meat and milk and concentrate in the cellular material, we found that Potassium K^{40} is transferred to the milk by the same means and this also depends on a number of factors as the plant content of the element, the need of the animal body, metabolism and the quantity of the element disposed from the body.

Transfer factor TF

The transfer factor TF is the relation between specific activity of potassium K^{40} in plant (C_p) to the specific activity of potassium K^{40} in soil (C_s) for all locations was plotted in fig (5) .It should be noted that the relation isn't linear for a number of reasons, the first stems from the differences in climate and geographical conditions of the selected sites and the differences in the conditions of germination and related to it. The second reason of non-linearity is that a phenomenon of saturation associates with plant as the plant takes only sufficient supply of elements that enter in its constructing and needs. An empirical equation between C_p and C_s has been obtained as shown below. This equation can be used in absence of local measurements.

$$\mathbf{C_p = 2.863\, C_s^{\,0.7583}} \quad \text{.........(3)}$$

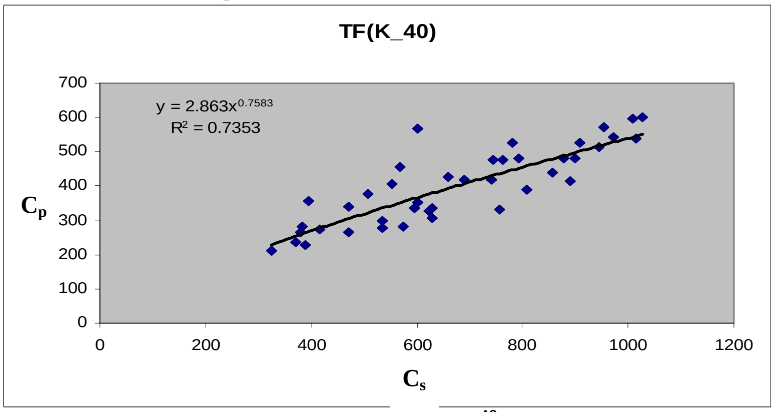

Figure (5) Specific activity of potassium K^{40} in plant C_p to the specific activity of potassium K^{40} in soil C_s

Table (5) summarizes the transfer factor of Potassium K^{40}. It's concentration ranged between 0.439 and 0.943. This TF is reasonable when taking into consideration that Potassium K is one of the main components in soil, plant and milk and that it is relatively abundant in the earth's crust. It has been found that this value corresponds to the findings of Tsukada and Hasegawa (2000) as the transfer coefficient ranged between 0.1-1. The rate may differ from one site to another according to the difference in the environment and the type of plant under investigation .

Table (5) Summarizes the transfer factor rate of Potassium K^{40}

No.	Sample	Location	$TF=C_p/C_s$ (K^{40})
1.	A1	Bahweza	0.49
2.	A2	Al-Bosef	0.674
3.	A3	Owenat	0.649
4.	A4	Al-Zewania	0.943
5.	A5	Earmga	0.624
6.	A6	Al-Namrod	0.737
7.	A7	Al-Shamciat	0.481
8.	A8	Kaber Al-Abd	0.565
9.	A9	Felfel	0.731
10.	A10	Al-Koba (near R22)	0.696
11.	B1	Al-Sada	0.534
12.	B2	Al-Hamdania	0.559
13.	B3	Baltla	0.524
14.	B4	SnJar	0.589
15.	B5	Rbeha	0.543
16.	B6	Al-Kaosh	0.583
17.	B7	Al-Ramzania	0.739
18.	B8	Hamam Al- Alel	0.59
19.	B9	Baathra (near R27)	0.439
20.	B10	Al-Bahj	0.466
21.	C1	Dam of Mousl	0.65
22.	C2	Al Rashidia	0.536
23.	C3	Near Al-Kindi Establishment	0.639
24.	C4	Al- Noran(R25)	0.638
25.	C5	Al-Salalat	0.562
26.	C6	Bashiqa	0.604
27.	C7	Ien Sfny	0.663
28.	C8	Dear Maty(R27)	0.597
29.	C9	AL-Shora	0.723
30.	C10	Shersaka(R41)	0.564
31.	D1	Hor Sabad	0.513
32.	D2	Badosh	0.657
33.	D3	Sherihan(R22)	0.489
34.	D4	Tal koj	0.548
35.	D5	Al Salahia(R18)	0.905
36.	D6	The bridge of Mandan	0.514
37.	D7	Tal Afar	0.529
38.	D8	Al- Kinde	0.558
39.	D9	Al-Arig	0.608
40.	D10	Al- Salamia	0.694
41.	D11	Talkif	0.591

The Effective Dose Equivalent EDE

To calculate the levels of danger and comparing the results with the permissible international levels, the EDE (µsv/y) of Potassium K^{40} from milk intake was calculated using the following formula .

$$\textbf{EDE (µsv/y) = F × C (Bq/l)…………(4)}$$

Where:

C (Bq/l) is the concentration of potassium K^{40}

F is the conversion factor = 0.51 $µsv.l.Bq^{-1}.y^{-1}$ (each 32 Bq/l is equivalent to 16.32 µsv/y for adult) ICRP(1989), Shinber (1999).

Table (6) represents the values of EDE and its range between 34.1 and 81.6 µsv/y.

Table (6) Summarize the concentration (Bq/l) and the EDE (µsv/y) of potassium K^{40} from milk intake

No.	Sample	Location	Bq/l	EDE (K^{40})
1.	A1	Bahweza	82.8	42.2
2.	A2	Al-Bosef	137.5	70.1
3.	A3	Owenat	117.3	59.8
4.	A4	Al-Zewania	133.8	68.2
5.	A5	Earmga	155.1	79.1
6.	A6	Al-Namrod	83.6	42.6
7.	A7	Al-Shamciat	118.1	60.2
8.	A8	Kaber Al-Abd	102.6	52.3
9.	A9	Felfel	101.5	51.8
10.	A10	Al-Koba (near R22)	133.4	68.0
11.	B1	Al-Sada	145.9	74.4
12.	B2	Al-Hamdania	157.2	80.2
13.	B3	Baltla	101.5	51.8
14.	B4	SnJar	140.0	71.4
15.	B5	Rbeha	104.1	53.1
16.	B6	Al-Kaosh	93.4	47.6
17.	B7	Al-Ramzania	86.7	44.2
18.	B8	Hamam Al- Alel	67.4	34.4
19.	B9	Baathra (near R27)	91.7	46.8
20.	B10	Al-Bahj	126.8	64.7
21.	C1	Dam of Mousl	66.8	34.1
22.	C2	Al Rashidia	101.7	51.9
23.	C3	Near Al-Kindi Establishment	71.7	36.6
24.	C4	Al- Noran(R25)	133.4	68.0
25.	C5	Al-Salalat	83.4	42.5

26.	C6	Bashiqa	137.4	70.1
27.	C7	Ien Sfny	150.1	76.6
28.	C8	Dear Maty(R27)	158.4	80.8
29.	C9	AL-Shora	102.0	52.0
30.	C10	Shersaka(R41)	127.0	64.8
31.	D1	Hor Sabad	124.9	63.7
32.	D2	Badosh	67.9	34.6
33.	D3	Sherihan(R22)	70.9	36.2
34.	D4	Tal koj	135.8	69.3
35.	D5	Al Salahia(R18)	104.1	53.1
36.	D6	The bridge of Mandan	69.7	35.5
37.	D7	Tal Afar	160.0	81.6
38.	D8	Al- Kinde	119.9	61.1
39.	D9	Al-Arig	133.4	68.0
40.	D10	Al- Salamia	93.4	47.6
41.	D11	Talkif	150.1	76.6

Conclusion

From the results obtained, it can be concluded that, the level of K^{40} is reasonable in soil, plant and milk and falling in the range of other countries worldwide. It is apparent that the difference in the levels of radiation activity is due to the differences in the geological and geographical nature of these regions. The empirical equation estimated for transfer factor can be used in absence of local measurement. Finally the EDE from milk intake fall within the permissible international levels 1mSv/y.

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