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Determination of the Concentration of Radionuclide in Tomato samples collected from The North-East Region of Libya

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Abstract The radio isotopic analysis of vegetation is vital. It acts as a tool in indicating contaminated vegetables which are consumed by humans on a daily basis. Hence isotopic analysis has become of interest worldwide including Libya.This work aims at measurement and evaluation of activity concentrations of radionuclides in tomato and corresponding soil samples in the north east region of Libya. The concentration of radionuclides in the soil and tomato samples was measured using gamma spectroscopy described below. The radioactive analysis of soil shows the average activity concentration of ^{40}K, ^{238}U and ^{232}Th series, and ^{137}Cs in soil are 535.9, 31.9, 33.6 and 11.4 Bq/kg dry weight respectively. The radioactive analysis of tomato samples showed that ^{40}K is the only radionuclide detected with an average of 1908 Bq/kg dry weight. The average radionuclide concentration ratio (C.R.) of ^{40}K for tomato is 2.8.

Keywords: concentration ratio, isotopic analysis, ^{40}K concentrations, radionuclides, tomato

تحديد تركيز النويدات المشعة في عينات من الطماطم من منطقة شمال شرق ليبيا

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الملخص تحليل النظائر المشعة في الخضروات أصبح من الضروريات لأنه يمثل الاداة الفعّالة لمعرفة مدى تلوث الخضروات التي يستهلكها الافراد يوميا بالمواد المشعة، وبالتالي أصبح تحليل النظائر ذا أهمية كبيرة في دول العالم ومن ضمنها ليبيا. الغرض من هذا البحث هو قياس وحساب تركيز النشاط الاشعاعي للنويدات المشعة في عينات من الطماطم وعينات من التربة في المنطقة المذكورة. تم أخذ القياسات باستخدام مطياف جاما، وقد أظهرت هذه القياسات أن متوسط التركيز الاشعاعي في التربة (وزن جاف) للعناصر المشعة (^{40}K، سلسلة ^{238}U، سلسلة ^{232}Th و ^{137}Cs) هي (535.9، 31.9، 33.6 و 11.4 بوحدة Bq/kg) على التوالي. أما بالنسبة إلى عينات الطماطم (وزن جاف) فلم يوجد بها إلا عنصر (^{40}K) فقط،، وكان متوسط التركيز الاشعاعي لهذا العنصر (1908 بوحدة Bq/kg) و كان متوسط معدل تركيز هذا العنصر في الطماطم للعينات هو . 2.8

الكلمات المفتاحية: نسبة التركيز، تحليل النظائر، تركيز البوتاسيوم 40، النويدات، الطماطم.

Introduction:

The north-eastern of Libya from the city of Benghazi to the Libyan-Egyptian borders is about 600 km in length with an average width of about 20 km. This covers an area of 12,000 km^2, the region under study is part of this area. This region represents the most inhabited area. Its population represents about one third of the total present Libyan population. From Benghazi to El-Bayda the average rainfall is 250 – 350 mm, and the soil in this area is of alluvial origin. A few springs emanating from mountain base are used for irrigation. Conditions in this area are primarily favorable for horticulture and vegetable growing. One of the biggest problems facing the world is control of nuclear radiation. Even though nuclear radiation is an unavoidable part of our natural environment. Apart from cosmic rays, the soil of the earth is an important source of nuclear radiation. A number of natural radionuclides, to name a few are uranium (^{238}U), thorium (^{232}Th) and their decay products (^{226}Ra, ^{212}Pb, etc.) and potassium isotope (^{40}K) are observed as inherent soil contents. These natural radionuclides contribute to the radiation exposure, externally through gamma ray emission and also internally through inhalation and the food chain [1]. The use of nuclear technology also generates many long-lived radionuclides, of which ^{137}Cs is the most abundant one [2]. This artificial radionuclide enters the environment largely as a result of nuclear weapon tests, accidents in nuclear power plants and the geological repository of nuclear wastes and then spreads out into distant locations through atmospheric convection [3]. Samples of soil and tomato were collected from the area of interest, and prepared for measurements of the Concentration of Radionuclide using hyper pure Germanium detector type TENNELEC, detector model $CPVDS30-30195$, serial number 2188 with crystal diameter of 58 mm and length 59.2 mm. The end cap to crystal is < 5 mm, the germanium dead layer thickness is 600 mm, and the detector active volume is 155 cc with relative photopeak efficiency of about 30% and resolution (full width at half maximum FWHM) of 1.9 keV for 1.33 MeV gamma line of Co-60. The detector device is a P-type with positive polarity and operating voltage of $+2300V$. The used detector can efficiently measure gamma emission in the energy range from 3 keV to 3 MeV.

The calibration of the detection system was performed against the standard sources provided by International Atomic Energy Agency (IAEA).

Experimental procedures and sampling collection: Tomato was selected to go into sample based on individual diet and consumption statistics. This selection is due to the concern over short term effect [4]. The samples were collected from the same field or region of soil samples wherever possible in order to make a correlation between them, as shown in figure (1). Twenty tomato samples were collected from the location sites in the investigated area. Tomato samples were taken as soft red fruits exactly in the same state as their consumption by human, washed by fresh water for removing the dust and mud. The samples were weighed individually, cut into slices, air dried in open air for a few days and dried in an oven at 85℃ for 12 hours [5]. The samples were weighted again to determine their water content, each sample was crushed and mixed thoroughly to be homogenized and shaken in a 2 mm sieve shaker and then transferred to marinelli beakers of 100 ml capacity, weighed and carefully sealed for 4 weeks to reach secular equilibrium for gamma activity measurement. The measurements of concentration of radionuclides in soil and tomato were then carried out.

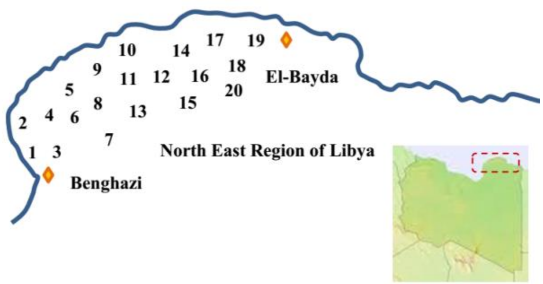

figure (1): Shows the sites of collected tomato samples.

Results and Discussion: Mechanical analysis was carried out to determine soil sample type according to clay, silt, and sand percentages. The results of this analysis are shown in table (1).

Table (1): mechanical analysis of soil samples

site number	silt %	clay %	fine sand %	rough sand %	soil type
1	23.15	23.75	48.42	3.10	SCL
2	18.7	7.90	55.36	17.50	SL
3	27.80	17.00	39.49	7.25	SL
4	24.40	22.50	48.36	3.35	SCL
5	24.40	22.50	48.36	3.35	SCL
6	17.00	9.50	57.00	15.90	SL
7	14.40	12.50	55.33	17.15	SL
8	20.75	13.25	53.23	8.00	SL
9	20.65	7.50	56.86	14.40	SL
10	13.70	10.40	58.35	17.00	SL
11	24.95	9.15	56.33	5.70	SL
12	12.45	9.15	62.22	15.60	SL
13	23.25	13.25	55.11	5.00	SL
14	23.25	13.25	55.11	5.00	SL
15	23.25	13.25	55.11	5.00	SL
16	23.25	13.25	55.11	5.00	SL
17	24.40	12.50	51.63	11.15	SL
18	30.75	8.25	44.26	16.50	L
19	19.95	17.90	54.81	5.50	SL
20	23.25	13.25	50.87	12.40	SL

*SCL= Sandy Clay Loam, SL= Sandy Loam, L=loam

Chemical analysis of soil samples including pH, calcium carbonate, electro conductivity (EC), and organic matter content of soil were also carried out. The results of this analysis are shown in table (2).

Table (2): chemical analysis of soil samples

site number	pH value	$CaCO_3$ %	EC %	Organic matter %
1	7.8	13.8	0.26	2.85
2	7.8	4.50	0.27	2.05
3	8.4	37.3	0.54	0.89
4	7.9	3.10	0.29	3.98
5	7.9	3.10	0.29	3.98
6	8.1	21.0	0.24	3.39
7	7.8	2.90	0.33	4.31
8	7.6	4.50	0.31	4.91
9	7.9	2.80	0.26	3.22
10	8.3	37.6	0.55	1.02
11	7.9	3.60	0.27	3.33
12	7.7	16.7	0.27	3.43
13	7.9	1.30	0.28	2.30
14	7.9	1.30	0.28	2.30
15	7.9	1.30	0.28	2.30
16	7.9	1.30	0.28	2.30
17	7.6	46.4	0.32	4.61
18	7.8	36.5	0.60	0.75
19	8.3	30.0	0.34	1.14
20	8.0	20.3	0.23	3.06

The efficiency calibration of HpGe detector was achieved using Ra-266 source and four different concentrations of KCl.

The concentrations that had been used were $16g/l$, $32g/l$, $64g/l$, and $128g/l$, which corresponds to 261.8 Bq/l, 532.6 Bq/l, 1047.2 Bq/l, and 2094.4 Bq/l respectively, and reference materials obtained from the Analytical Quality Control Service (AQCS) of the international Atomic Energy Agency (IAEA) [1].

The results of measurements of the concentration of the radionuclides in the collected soil and tomato samples are presented in tables (3) and (4) respectively. The maximum and minimum of each concentration are shown in bold.

Table (3): Concentration of Radionuclide in Soil (Bq/kg)

Site No.	^{40}K	^{238}U	^{232}Th	^{137}Cs
1	660.9±21.9	29.4±1.4	31.9±2.3	10.4±1.0
2	638.6±32.5	32.5±1.1	43.9±1.5	9.6±0.4
3	780.3±25.6	41.7±2.2	48.2±2.6	9.7±0.9
4	754.1±11.9	44.1±0.8	50.1±0.8	9.3±0.3
5	744.0±47.5	47.5±2.2	49.2±2.8	9.2±0.9
6	725.8±14.4	43.9±1.2	48.5±1.5	8.5±0.4
7	644.1±25.9	42.7±2.8	51.7±2.9	9.4±1.1
8	688.0±14.4	41.9±1.2	50.1±1.6	9.8±0.5
9	845.0±33.6	46.9±3.3	**67.8±4.3**	9.6±1.2
10	830.0±37.0	48.7±3.3	61.2±1.8	9.3±0.9
11	**858.7±32.7**	44.0±3.4	60.2±3.6	5.9±1.0
12	807.1±12.7	38.0±0.8	58.8±1.1	**5.4±0.2**
13	669.6±28.9	43.8±2.6	43.4±3.5	10.36±1.1
14	714.0±15.2	46.4±1.3	52.8±1.7	10.8±0.5
15	714.6±13.6	**48.3±1.2**	51.8±1.5	8.9±0.4
16	711.0±14.3	47.0±2.1	50.1±1.3	7.4±0.4
17	483.8±26.6	**23.6±2.5**	29.1±2.9	7.3±1.0
18	485.0±25.6	26.7±2.1	29.4±2.8	8.4±1.0
19	488.8±11.2	26.6±0.9	27.8±1.2	7.8±0.4
20	**452.4±20.9**	27.5±2.1	**24.6±2.2**	**12.4±1.0**

Table (4): Concentration of Radionuclide in tomato (Bq/kg)

Site No.	^{40}K	^{238}U	^{232}Th	^{137}Cs
1	1997.7±53.5	<DL	<DL	<DL
2	1858.0±51.4	<DL	<DL	<DL
3	**1488.8±63.9**	<DL	<DL	<DL
4	1745.2±45.9	<DL	<DL	<DL
5	1821.3±48.0	<DL	<DL	<DL
6	1820.7±47.7	<DL	<DL	<DL
7	1932.3±48.4	<DL	<DL	<DL
8	2214.6±66.8	<DL	<DL	<DL
9	2220.4±70.3	<DL	<DL	<DL
10	1960.0±60.0	<DL	<DL	<DL
11	1718.6±43.9	<DL	<DL	<DL
12	1637.2±59.9	<DL	<DL	<DL
13	1777.7±71.2	<DL	<DL	<DL
14	1903.1±50.8	<DL	<DL	<DL
15	1715.8±39.3	<DL	<DL	<DL
16	**2337.0±82.0**	<DL	<DL	<DL
17	1821.0±42.8	<DL	<DL	<DL
18	1750.9±48.9	<DL	<DL	<DL
19	1601.2±92.7	<DL	<DL	<DL
20	1622.1±89.7	<DL	<DL	<DL

<DL = Less than detection limit.

The activity concentration of ^{40}K in tomato samples varied from a low value of 1488.8 Bq/kg to a high one of 2337 Bq/kg, with an average of 1908 Bq/kg dry weight. The concentration ratio (C.R.) of ^{40}K for tomato was calculated using the formula [6].

$$C.R. = \frac{concentration\ in\ dry\ vegetable}{concentration\ in\ dry\ soil}$$

The concentration ratio (C.R.) of ^{40}K for tomato ranged from 1.90 to 3.82 with an average of 2.8. Table (5) summarizes the values of C.R. of radionuclides ^{40}K in tomato. maximum and minimum values are shown in bold and these values are illustrated in figure (2). Many studies have used concentration ratio to determine the ability of various plant species to absorb radionuclides from soils or other substrates [7]. The C.R. have been used in predicting the transport of radionuclides and other elements of interest through the food chain as well as in biogeochemical studies of radionuclides, substantial variability in C.R. values have been reported depending on soil properties and crop species [8,9]. In this work the selection of typical vegetation was based on consumption statistics. Tomato is consumed by human beings and therefor represent a direct pathway of radionuclides to man that is why we were concerned with concentration ratio rather than transfer factor [10].

Table (5): Activity Concentration Of ^{40}K in Tomato and in soil along with its Concentration Ratio (C.R.)

Site No.	Activity concentration in tomato Bq/kg)	Activity concentration in soil Bq/kg)	C.R.
1	1997.7±53.5	660.9±21.9	3.02
2	1858.0±51.4	638.6±32.5	2.90
3	**1488.8±63.9**	780.3±25.6	**1.90**
4	1745.2±45.9	754.1±11.9	2.31
5	1821.3±48.0	744.0±47.5	2.44
6	1820.7±47.7	725.8±14.4	2.50
7	1932.3±48.4	644.1±25.9	3.00
8	2214.6±66.8	688.0±14.4	3.21
9	2220.4±70.3	845.0±33.6	3.62
10	1960.0±60.0	830.0±37.0	2.36
11	1718.6±43.9	**858.7±32.7**	2.00
12	1637.2±59.9	807.1±12.7	2.02
13	1777.7±71.2	669.6±28.9	2.65
14	1903.1±50.8	714.0±15.2	2.66
15	1715.8±39.3	714.6±13.6	2.40
16	**2337.0±82.0**	711.0±14.3	3.28
17	1821.0±42.8	483.8±26.6	**3.82**
18	1750.9±48.9	485.0±25.6	3.61
19	1601.2±92.7	488.8±11.2	3.27
20	1622.1±89.7	**452.4±20.9**	3.58

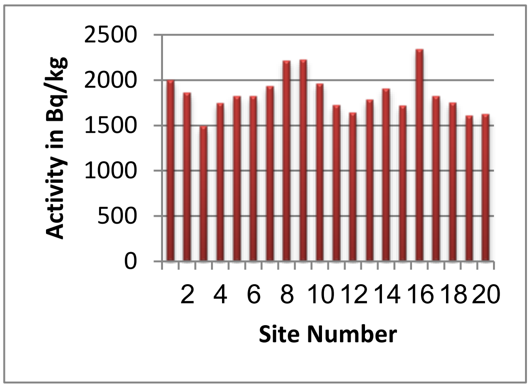

Figure (2): Average values of activity oncentration of ^{40}K in tomato

Conclusion: The average activity concentration of ^{40}K, ^{238}U and ^{232}Th series, and ^{137}Cs in soil are 535.9, 31.9, 33.6 and 11.4 Bq/kg dry weight respectively. The radioactive analysis of tomato samples showed that ^{40}K is the only radionuclide detected with an average of 1908 Bq/kg of dry weight. The activity concentration of ^{238}U and ^{232}Th series and ^{137}Cs were found to be less than the detection limit ($< DL$). The results showed that the calculated average concentration ratio (C.R) of ^{40}K for tomato is 2.8 which seems to be normal for the type of crop species [11,12]. And since the extent to which plants absorb radionuclides from soil depends on many factors and on the extent to which it is chemically available for transport to root zone endings and its translocation to edible portion of the plant. The absence of other radionuclides can also be attributed to soil characteristics and plant watering. Therefore we conclude that the investigated area is suitable for tomato farming. Results of mechanical and chemical analysis will help to identify such type of area.

References:

[1]- IAEA. Measurement of radionuclides in food and the environment. 1989. A guidebook, Technical Report Series No. 295. Vienna.

[2]- Hu QH, Weng JQ, Wang JS. 2010. Sources of anthropogenic radionuclides in the environment, a review. J Environ Radioact 101:426–37.

[3]- Giuliani S, Triulzi C, Vaghi M. 2003. Anthropogenic radionuclides in plants, animals and their environments in Antarctica. Marine Ecological Journal 2:5–15.

[4]- Harley, J. H. (ed) 1983. EML procedures manual, HASL 300. Environmental Measurement Laboratory, U.S. Department of Energy Washington D.C.

[5]- Elorfi, S. Y., Imsallim, M., Abdalla, Y. K. 2018. A Technique of Efficiency Calibration of HPGe Detector. Libyan Journal of Science & Technology 7:2 100−102

[6]- Tovedral, H. 1986. Analysis of grass samples in Sweden after the Chernobyl accident. Studsvik Energitenik AB S-61182 Nyking Sweden, (IAEA/RL/147, July, 1987), “The determination of radionuclides in grass ecosystem samples by J. J. LaBrecque, R. Schelenz and R. W. Perkins.

[7]- Shyamal Ranjan Chakraborty, Rezaul Azim*, A. K. M. Rezaur Rahman and Rashmi Sarke. 2013. Radioactivity Concentrations in Soil and Transfer Factors of Radionuclides from Soil to Grass and Plants in the Chittagong City of Bangladesh. Journal of Physical Science, 24(1): 95–113

[8]- Nedzad Gradascevic’, Lejla Saracevic’, and Davorin Samek’ 2015. Activity concentration of natural radionuclides in hay and grass from certain areas of Bosnia and Herzegovina. Veterinaria, vol. 64, No. 1

[9]- Till, J.E. and Meyer, H. R. 1983. “Radiological Assessment” Washington , United States Nuclear Regulatory Comission, Report No. NUREG/CR-3332-ORNL-5968

[10]- Eisenbered, M. 1987 “Environmental Radioactivity from Natural, Industrial and Military Sources” Third Edition, Academic Press, Inc. NewYork

[11]- Paul Linsalata, Robert Morse, Helen Ford, Merril Eisenbud, E Penna, Franca N. Lobao, I. Sachett, M. Cados, 1989. An assessment of soil - to- plant concentration ratios for some natural analogues of transuranic elements. Health Physics 56(1), 33-46

[12]- UNSCEAR 1993. Exposures from National Sources of Radiation – United Nations Scientific Committee on Effects of Atomic Radiation”, Report to the General Assembly.