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Radionuclides Activity and Radiological Hazard Assessment in Bananas Samples Exported to Iraq

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Abstract

The average concentration of radionuclide's in the various banana samples were collected from being the most popular markets in Baghdad city - Iraq were measured by use Sodium Iodide Thallium [NaI(Tl)] detector. The radionuclide's observed with reliable regularity belonged to the series-decay naturally occurring radionuclide's headed by ^{232}U and ^{232}Th as well as the non-series nuclide, ^{40}K and ^{137}Cs. The average concentration of ^{40}K was found the least average concentration value recorded as876.74625Bq kg^{-1}.The average concentration of ^{238}U was 28.6425Bqkg^{-1}for ^{232}Th, it was found to have the average concentration 14.1805 Bqkg^{-1}. The cesium concentration in the sample was found in the healthy range.

Keywords: Banana, radioactivity, specific activity, ^{23}U, ^{232}Th, ^{40}K, ^{137}Cs

النظائر المشعة وتقييم المخاطر الاشعاعية في عينات الموز المصدر الى العراق

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الخلاصة

تم حساب تركيز النظائر المشعة في نماذج مختلفة من الموز التي جمعت من الاسواق المحلية في مدينة بغداد– العراق باستخدام كاشف ايوديد الصوديوم المطعم بالثاليوم ((NaI(Tl)). النظائر المشعة التي تم ملاحظتها تمثل سلسلة اليورانيوم 235 وسلسلة الثوريوم232 وكذلك النظائر المنفردة البوتاسيوم40 والسيزيوم137. معدل الفعالية النوعية لنظير البوتاسيوم هو 876.74625 بيكرل/كغم،ولليورانيوم كان 28.6425 بيكرل / كغم وللثوريوم كان 14.1805 بيكرل/ كغم. وكانت الفعالية النوعية لنظير السيزيوم 137 ضمن المدى المسموح .

Introduction:

Our world is radioactive and over 60 radionuclide's can be found in nature in air, water and soil, and additionally in our body, being that we are products of our environment. Every day, we ingest/inhale nuclides when we breathe, eat and drink. There is no where on earth that you can get away from natural radioactivity [1]. Distribution of naturally occurring radionuclide's mainly ^{238}U, ^{232}Th and ^{40}K and other radioactive elements depends on the main material distribution. The main sources of the external γ-radiation are the radionuclide's of the *U* and *Th* series and *K* [2]. Radium and its ultimate precursor uranium in the ground are the source ofradon and α- radioactive inert gas. As an inert gas and having sufficiently long lifetime (3.8 days) it can move freely through the materials like soil, sand, rock etc [3]. Radon appears when radium (^{226}Ra) – ^{238}U-family division product – decays.

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All foods are slightly radioactive, some more than others. All food sources combined expose a person to about 0.4 mSv per year on average. Fruits and vegetables are very vital in human diet, the presence of natural radionuclides (^{40}K, ^{238}U and ^{232}Th) in them results in radiological implication not only in the food but also on the populace consuming these food [4]. Bananas are cultivated in nearly all tropical regions of the world providing a staple starchy food for 80 million people and important source of income. Bananas are grown in nearly 130 countries. The more of the contaminated food ingested the more the risk of man‘s exposure.

This study investigated the activity concentration of ^{40}K, ^{232}U,^{232}Th and^{137}Csin some banana species and its shells popularly consumed in Baghdad city, Iraq, in order to improve the understanding on the effects on peoples. The radium equivalent, the external hazard index, the absorbed dose and the annual effective dose were assessed and compared with results of the worldwide average value in the United Nations Scientific Committee on the Effects of Atomic Radiation report [5].

Material and Methods

Four samples of different types of banana species were collected from different markets in Baghdad city. A total samples were collected as 3 samples from each exported country (Ecuador, Costarica and Philippine). The edible portion was sliced and sun dried to a constant weight [6]. The well dried samples were ground into powder with electrical blender and with 2mm wire mesh. Each sample was packed in 50g lot by weight and sealed in airtight plastic container. The samples were thereafter left for 28 days in order for gaseous daughters of ^{40}K, ^{232}U, ^{232}Th and$Cs^{137}$to reach secular equilibrium before counting was taken [7]. Radioactivity counting done by a 76mm x76mm NaI detector lead shielded which was coupled to a 10 plus multi-channel analyzer through a preamplifier base. The detector has a resolution of about 8% at 0.662 MeV line of ^{137}Cs, each sample was counted for 36000 seconds.

The purpose of energy calibration that we done is to obtain a relationship between a peak positions in the spectrum against the corresponding gamma-ray energy. This calibration should cover the entire energy range of interest. The measured gamma-ray energies are only used to identify the nuclides in the spectra. Any uncertainty in the measured gamma-ray energy does not affect the quantification of the final combined uncertainty measurements as shown in Figure-1. Also the efficiency calibration aims to derive a relationship between the absolute full energy peak efficiency of the gamma-ray spectroscopy system and the energy. The statistical uncertainty associated with the number of counts in the peaks; along with uncertainty in the nuclear data contribute to the combined uncertainty of the efficiency calibration as shown in Figure-2.

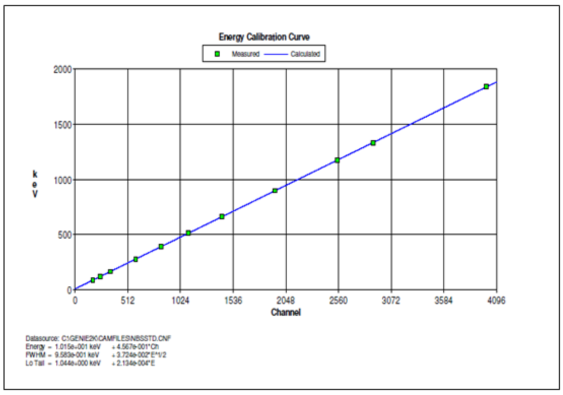

Figure 1- The efficiency calibration curve.

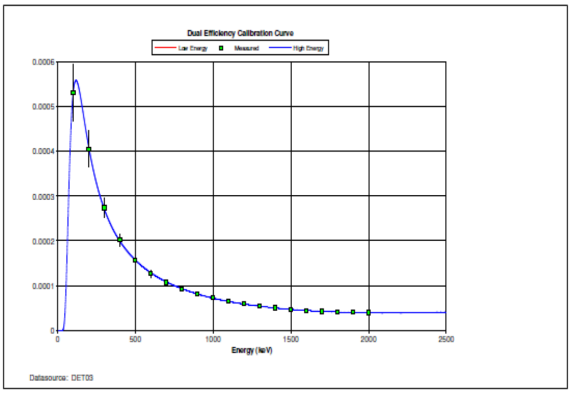

Figure 2- The energy calibration curve.

Results and Discussion:

Activity Concentration

The activity concentrations in ($Bq.kg^{-1}$) for the eight studied samples calculated for each of the ^{238}U (^{226}Ra),^{232}Th(^{228}Ac) and ^{40}Kradionuclide's by using eq's. [8].

$$A_s = \frac{A}{W}(Bq.kg^{-1}) \text{ and } A = \frac{A_{net}}{\varepsilon \times I_\gamma \times t}(Bq)$$

Where A is the activity of the isotope, W is the weight of the sample, A_{net} is the net area of the total absorption line, I_γ the absolute intensity of the transition, t the sample counting time and ε the gamma efficiency evaluated in function of the transition energy.

The results are listed in Table-1 and shown in Figure-3. The data show that radioactive equilibrium between progenies in ^{238}U and ^{232}Th series for all samples can be assumed.

The activity concentration of ^{40}K ranged from 562.2Bq/kg in Slobana Costaricato 81012.85 Bq/kg in shell Sabrostar one. The highest activity concentration of ^{238}U was found in shell Senorita sample 54.11 Bq/kg, while the lowest concentration was found in Premium Ecuador0.17 Bq/kg. The activity concentration of ^{232}Th have values in shell Senorita is 41.12 Bq/kg and 0.654 Bq/kg in Senorita. For ^{137}Cs it was found the 30.87 Bq/kg as highest value in shell Senorita and 1.84 Bq/kg as lowest value of activity in Premium Ecuador. Same results were found in the shells of samples where it found for ^{40}K to be the highest in all the samples. However, the values obtained for ^{40}K were very low compared to values obtained for other locally produced food stuffs in the area. Since the values obtained for ^{40}K were almost within the same range in all the samples, this could put the source of ^{40}K as being from samples of the potassium rich. The mean activity concentrations of ^{40}K and ^{232}U were found to be high in876.74625 Bq/kg and 28.6425Bq/kg respectively, showing that this particular specie probably has an affinity for these radionuclides.

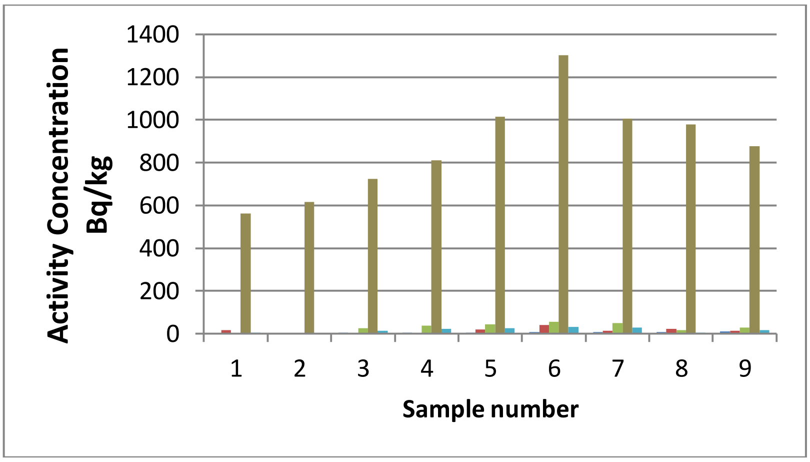

Figure 3- Activity concentration for each sample

Calculation of Radiological Effects

To represent the activity levels of ^{226}Ra, ^{232}Th and ^{40}K by a single quantity, which takes into account the radiation hazards associated with them, a common radiological index has been introduced called radium equivalent activity (*Raeq*) in Bq.kg^{-1} to compare the specific activity of materials containing different amounts of ^{226}Ra,^{232}Th and ^{40}K[9]:

$$Ra_{eq} = C_{Ra} + 1.43C_{Th} + 0.077C_K$$

Where, C_{Ra}, C_{Th} and C_K are the specific activities of $^{226}Ra$$^{232}Th$ and ^{40}K respectively. This equation is based on the estimation that 10 Bq.kg^{-1} of ^{226}Ra equal 7 Bq.kg^{-1} of ^{232}Th and 130 Bq/kg of ^{40}K produce equal gamma dose. The maximum value of Ra_{eq} is must be < 370 Bq·kg^{-1} for safe use.

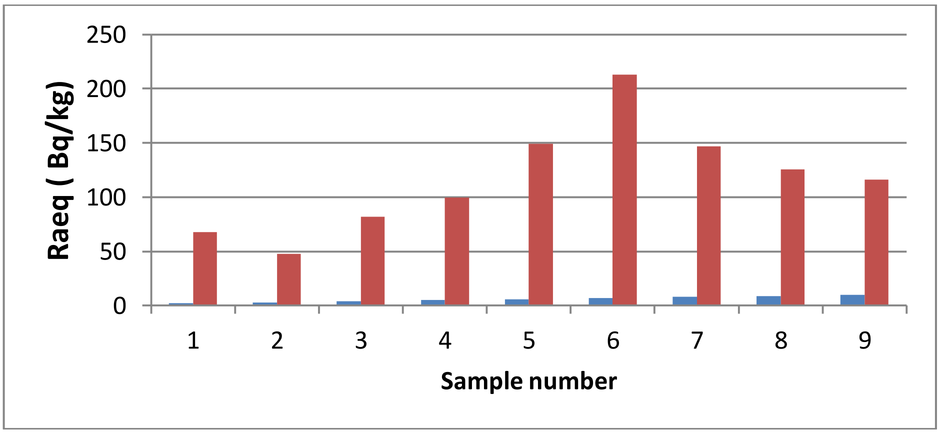

Figure 4- Radium equivalent activity comparing with standard one

A widely used hazard index (reflecting the external exposure) called the external hazard index is defined as follows [10]:

$$H_{ex} = \frac{C_{Ra}}{370} + \frac{C_{Th}}{259} + \frac{C_K}{4810}$$

The calculated values of H_{ex} (Table 2) for samples were between 0.128499and 0.575694 (mean: 0.314439). Radioactivity may cause harm to the population if the calculated value of H_{ex} is higher than unity.

For the internal hazard index (Hin) [11]:

$$H_{in} = \frac{C_{Ra}}{185} + \frac{C_{Yh}}{259} + \frac{C_K}{4.810}$$

The average values for samples were 0.391851. The average values of H_{in}in both bananas and shells were less than unity.

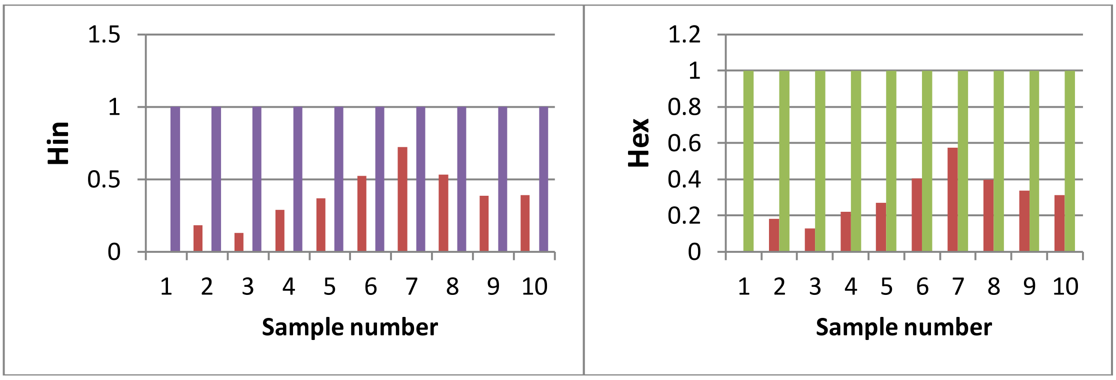

Figure 5- External and Internal Hazard Index

The absorbed dose rates (D) due to gamma radiations in air at 1m above the ground surface for the uniform distribution of the naturally occurring radionuclides (^{226}Ra, ^{232}Th and ^{40}K) were calculated based on guidelines provided by UNSCEAR 2000[10]. The dose (D) was calculated [10]:

$$D = 0.462C_{Ra} + 0.604C_{Th} + 0.0417C_K$$

The average values of D for samples were 58.59924nGy h^{-1}. This value was higher than the mean value of 51 nGy h^{-1}recommended in the UNSCEAR (2000) report.

For the general public who work outside and inside the fields of bananas, the annual effective dose was calculated in terms of outdoor (E_{out}) and indoor (E_{in}), respectively. The conversion factor (0.7 $SvGy^{-1}$) and (0.2) (0.8) outdoor and indoor occupancy factors, respectively, were used to estimate E_{out} and E_{in}[9]

$$E_{outdoor} = observed\ dose\ [G_y / h] \times 8766\ h / y\ \times\ 0.7\ [\text{Sy/Gy}]\ \times\ 0.2 \times 10^{-6}$$

$$E_{intdoor} = observed\ dose\ [G_y / h] \times 8766\ h / y\ \times\ 0.7\ [\text{Sy/Gy}]\ \times\ 0.8 \times 10^{-6}$$

Where 8766 h y^{-1} is number of hours in one year (leap year was taken in account), and10^{-6} is the conversion factor between nano and milli.

The results obtained for E_{out} and E_{in} are shown in Table-2. The average values of E_{out} and E_{in} for samples were 0.071866 and 0.287464, respectively.

These values were less than the lower limit of 20 mSv y^{-1} for radiation workers and even lower than the recommended level of 1 mSv y^{-1} for the general population (ICRP, 1991) [12] and we don't have good resolution picture if we plot it due to the small results we have.

Another radiation hazard index, the representative level index, $I_{\gamma r}$, used to estimate the level of γ-radiation hazard associated with the natural radionuclides in investigated samples, to examine whether the samples meets these limits of dose criteria. It defined as [7]:

$$I_{\gamma r} = \frac{C_{Ra}}{150} + \frac{C_{Th}}{100} + \frac{C_K}{1500}$$

The value the representative level index $I_{\gamma r}$ must be less than unity for the radiation hazard to be negligible, so the average value of this index is 0.917253 while the highest value found in three shields (5, 6, 7) and higher than the internationally accepted value 1.

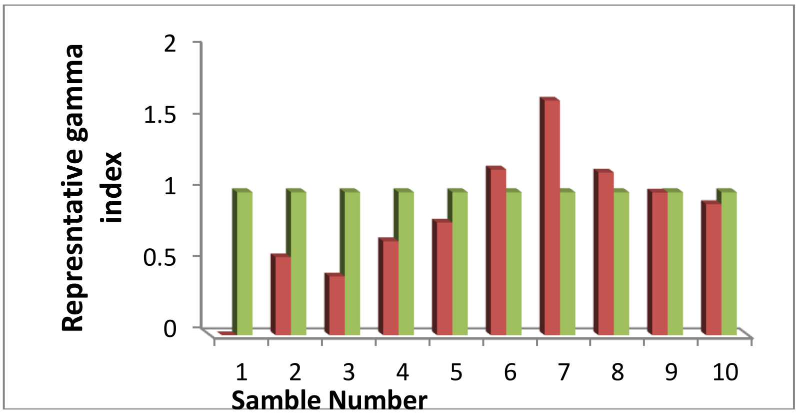

Figure 6- Representative gamma index compared with standard value.

The element ^{137}Cs dose radiation results comparing with ^{40}K. The cesium is man-made unwelcome contamination, while ^{40}K is always included in the essential macronutrient Potassium, which plays an important role in health. Our calculation show that a healthy intake of ^{40}K and ^{137}Cs (16.757) that comparing with world limits **(**the maximum allowable dose for ^{137}Cs in adult food is 100 Bq.kg^{-1} in Japan, 1000 Bq.kg^{-1} in the EU and 1200 Bq.kg^{-1} in the US**).**

Table 1- Activity concentration of radionuclide

Sample Number	**Sample name**	**Activity concentration (Bq/kg)**			
		^{232}Th	^{232}U	^{40}K	^{137}Cs
1	SlobanaCostarica	16.72	0.46	562.2	5.8
2	Premium Ecuador		0.17	615.87	1.84
3	Senorita	0.654	25.15	724.63	14.42
4	Sabrostar		37	810.7	21.24
5	Shell Sabrostar	19.12	44	1012.85	25.22
6	Shell Senorita	41.12	54.11	1302	30.87
7	Shell SlobanaCostarica	13	50.65	1006.48	29
8	Shell Premium Ecuador	22.83	17.6	979.24	5.67
Average		**14.1805**	**28.6425**	**876.74625**	**16.7575**

Conclusions

It is shown that the activity concentration of U-238, Th-232 and K-40 present in most of the studied are relatively lower that the average of worldwide concentration as it acceptable dose limits of both the UNSCEAR (1988) and the ICRP (1991) and it can therefore be inferred from the results obtained that the people living in Baghdad area generally receive a acceptable dose. This particular specie has to be given close monitoring because of relatively higher radiation level which is very close to the average acceptable limits of UNSCEAR (1988). Thus, the concentration values obtained indicate that the studied species in this area fall within low-level background radiation since values fall below the UNSCEAR and ICRP dose limits. It is expected that these data, which represent pioneering data for the study area, will serve as baseline data. These could be used to provide good estimate resulting from external exposure of the inhabitants of the area to ionizing radiation in a further research work.

Table 2: The hazard indices

Sample Number	sample name	*Ra_{eq} (Bq/Kg)*	*H_{ex}*	*H_{in}*	*D(nGy/h)*	*Eout*	*Ein*	*Iγr*
1	SlobanaCostarica	67.659	0.182681	0.183924	34.03938	0.041746	0.166984	0.545067
2	Premium Ecuador	47.59199	0.128499	0.128958	25.76032	0.031592	0.12637	0.411713
3	Senorita	81.88173	0.221149	0.289122	42.24251	0.051806	0.207225	0.657293
4	Sabrostar	99.4239	0.268545	0.368545	50.90019	0.062424	0.249696	0.787133
5	Shell Sabrostar	149.3311	0.403313	0.522232	74.43737	0.09129	0.36516	1.159767
6	Shell Senorita	213.1656	0.575694	0.721937	104.8277	0.128561	0.514243	1.639933
7	Shell SlobanaCostarica	146.739	0.396332	0.533224	73.44352	0.090071	0.360285	1.138653
8	Shell Premium Ecuador	125.6484	0.339298	0.386866	63.14294	0.077438	0.309754	0.99846
Average		**116.4301**	**0.314439**	**0.391851**	**58.59924**	**0.071866**	**0.287464**	**0.917253**

References

1. Zaini, M. A., H., Ahmad S., Mohmat O. and Abdul K. **2008**.An Assessment of Absorbed Dose Radition Hazard Index from Natural Radition. *The Malaysian Journal of Analytical Sciences*, 12(1), pp:295-304.
2. Yan-Xin, Yang, Xin-min Wu, Zhong-ying Jiang, Wei-Xing, Ji-gen Lu, Jun Lin, LeiMing Wang and Yuan-fu Hisa.**2005**. RaditionCncetrations in soils of theXiazhuanggranit area, Chaina., *Applied Radiation and Isotopes*, 63, pp:255–259.
3. Mahur, A. K., Kumar, R., Mishra, M., Ali, S. A., Sonkawade, R. G., Singh, B. P., Bhardwaj, V. N., Prasad, Rajendra. **2010**. Study of radon exhalation rate and natural radioactivity in soil samples collected from East Singhbhum Shear Zone in Jaduguda U-Mines Area, *Jharkhand, India and its Radiological Implications Indian Journal of Pure & Applied Physics*, 48, pp: 486–492.
4. Aborisade, C. A., Olomo, J. B and Tchokossa, P. **2003**. The Natural Radioactivity in Palm Oil Production at Olabisi Onabanjo University Oil Mill. *Nigerian Journal of Physics*. 15(1), pp: 17–19.
5. United Nations Scientific Committee. **1988**. on the Effects of Atomic Radiation Report to the General Assembly, with Annexes.
6. United Nations Scientific Committee on Effects of Atomic Radiation UNSCEAR. **1993.** Sources and Effects of Ionizing Radiation. Report to General Assembly, with Scientific Annexes, United Nations, New York. pp: 65-69.
7. Hasan H.I. and Mheemeed A. Kh.**2008**. Transfer of^{40}K from soil to plants in an agricultural field and its EDE from milk ingestion. *Damascus University Journal for Basic Sciences*. 24(2), pp:43-59.
8. Lu. Xinwei. **2005**. Natural radioactivity in some building materials of Xi'an, China, *Journal of Radiation Measurements*, 40(1), pp: 94-97.
9. Beretka, J. and Mathew, P. J. **1985**.Natural radioactivity of Australian Building materials, industrial wastes and by-products, *Health Phy*. 48, pp: 87-95.
10. United Nations Scientific Committee on the Effects of Atomic Radiation UNSCEAR.**2000.** Effects and risks of ionizingradiations. New York: United Nations.
11. International Atomic Energy Agency IAEA. **1989.** Measurement of radionuclides in food and the Environment. A Guidebook on Technical Report series No 295 (IAEA, Vienna).
12. International Commission of Radiological Protection (ICRP). **1991**. The l990-1991 Recommendations of the ICRP Publication 60.Annals, ICRP. 1 (1-3).