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# MONITORING OF $^{210}$Po AND URANIUM IN VEGETABLES AND FRUITS IN KUWAIT

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***Abstract.*** *Polonium-210 and uranium were monitored in most consumed vegetables and fruits in Kuwait following two validated procedures (radiochemical separation and then measurements using alpha spectrometry). The highest $^{210}$Po activity concentration was found in dates and bananas (111.4±25 and 107±16 mBq/kg respectively), while the lowest was monitored in green pepper (12 ± 2 mBq/kg). Uranium radioisotopes were below minimal detectable activity (0.25 Bq/kg). The importance of the study can be linked to the high local consumption of imported fruits and vegetables from different countries with different nuclear histories in addition to the fact that most Kuwaitis are being vegetarians nowadays. Conclusively, radiological data for natural alpha emitters have been established for fruits and vegetables in Kuwait, and they were found to agree with international similar data confirming their radiological safety. Future studies will be done determining gamma emitters in fruits and vegetables, in addition to the seafood analysis because it is the 1st source of $^{210}$Po incorporation.*

***Keywords:*** *minimal detectable activity, activity concentration, radiological data*

## 1. Introduction

Natural radioactivity in food is often ranging from 40 to 600 Bq/kg of food [1]. The significant radionuclide naturally occurring in food is Polonium-210 ($^{210}$Po) which undergoes alpha decay to stable $^{206}$Pb with a half-life of 138 days. $^{210}$Po, the decay progeny of $^{210}$Pb, is a highly chemo-toxic radionuclide with a relatively long effective biological half-life of 50 days [2].

Uranium is a natural radioactive element that originates from the earth's crust and is present in food, water, and soil. It decays by emitting alpha rays where its isotopes,$^{234}$U,$^{235}$U, and $^{238}$U, have very long half-lives. Uranium is toxic and can cause kidney damage if accumulated [3].

Establishing such a baseline in Kuwait is important for many reasons: the limitation of such available data, the existence of operational and pre-operational nuclear power plants in the region, and the probability that a nuclear incident may occur. Also, public concern is whether depleted uranium (DU) is present in Kuwait soil as a remnant after the Gulf War in 1990 and 1991.

Different international studies have been carried out assessing natural $^{210}$Po and uranium radioactivity in the food chain using different nuclear techniques [3-7]. In this study, two alpha radiochemical procedures were implemented and measurements were done using alpha spectrometry.

## 2. Methodology and Instrumentation

### *2.1. Sampling and sample preparation*

Highly consumed vegetables and fruits were collected from local groceries and farms based on a local survey total of 23 samples. The composite samples are the mix of two different origins samples to ensure the inclusion of all the available vegetables and fruits in Kuwait. Also, each local sample is the mix of three different local farms to attain more representative samples. Preparation of the vegetables and fruits samples includes thoroughly washing with distilled water, extracting the inedible parts, peeling, slicing, drying at 80 °C, grinding, homogenizing by sieving with 500µm mesh, and weighting.

### *2.2. Radioactivity determination*

Polonium-210 and uranium ($^{234}$U,$^{235}$U,$^{238}$U) have been analyzed following two validated radiochemical procedures as shown in Figure 1 [8] and Figure 2 [9]. Samples were counted for 4 days using a Canberra alpha spectrometry system equipped with 450-mm2 passive implanted planar silicon (PIPS) detectors at the second shelf where the detection efficiency is 15%.

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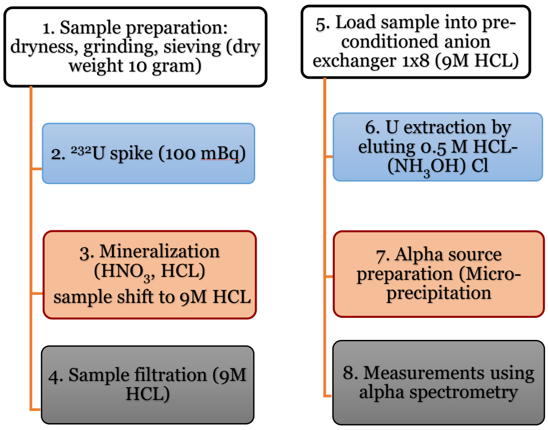


Figure 1. Uranium determination procedure [8]

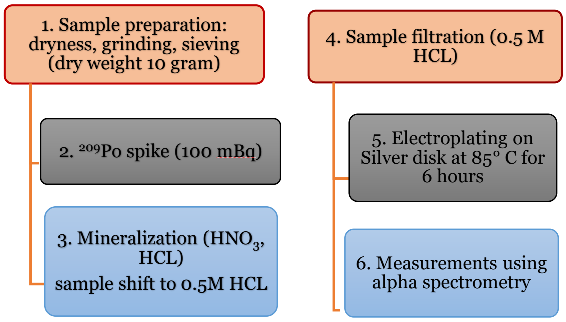


Figure 2. Polonium-210 determination procedure [9]

Radioactivity concentrations of the natural radionuclides $^{210}$Po and uranium radionuclides were calculated using the following equation:

$$A = \frac{a_T.m_T.r_n}{Ws.r_{nt}} f_T \tag{1}$$

where A is the radioactivity concentrations of alpha natural radionuclides ($^{210}$Po and uranium radionuclides) in Bq/kg unit, $a_T$ is the specific activity of tracers ($^{209}$Po and $^{232}$U) (Bq/g); $m_T$ is the mass of these tracer (g); $.r_n$ is the net count rate of the natural radionuclide ($^{210}$Po, $^{234}$U, and $^{238}$U) where the background subtraction is considered; $Ws$ is the weight of the sample (kg); $r_{nt}$ is the net count rate of the tracers $^{209}$Po and $^{232}$U (background subtracted); and $f_T$ is the decay correction factor of $^{209}$Po and $^{232}$U tracers between calibration date and measurement date. The associated uncertainty (u) of the radioactivity concentration of $^{210}$Po was calculated using the error propagation equation:

$$u(A) = \sqrt{\left(\frac{u(a_T)}{a_T}\right)^2 + \left(\frac{u(r_n)}{r_n}\right)^2 + \left(\frac{u(r_{nt})}{r_{nt}}\right)^2 + \left(\frac{u(W_s)}{W_s}\right)^2 + \left(\frac{u(m_t)}{m_t}\right)^2 + \left(\frac{u(f_T)}{f_T}\right)^2} \tag{2}$$

The Minimum Detectable Activity (MDA) was calculated by using the Curi formula:

$$MDA = \frac{\frac{2.71}{T_B} + 4.65\sqrt{R_B}}{E.W.I} \tag{3}$$

where $T_B$ is the background counting time; $R_B$ is the spectroscopy background count rate; $E$ is the counting efficiency percentage of the alpha detector; $W$ is the sample weight; and $I$ is the emission probability of an alpha particle (100%).

### *2.3. Quality assurance*

To ensure the credibility and integrity of our resulting data, analysis of certified reference materials (CRMs), IAEA -Spinach-330 and IAEA-447 moss, is carried out along with the analysis of each set of samples. Also, we participated in the annual IAEA proficiency test where our generated data were in agreement with IAEA-certified values.

## 3. Results and Discussion

Polonium-210 average activity concentration was monitored in all analyzed samples as shown in Figure 3, because it is a naturally originating in the earth's crust. It was the highest in ekhlas dates and bananas (111.4±25 and 107±16 mBq/kg, respectively), whereas the lowest was in green pepper (12.1 ± 1.65 mBq/kg). It was notable that $^{210}$Po level varied between samples and it can be related to several factors, such as the origin of samples, the use of phosphate fertilizers, and the atmospheric fallouts. These experimentally generated data are considered relatively comparable with the ones monitored in other countries as shown in Table 1 [4][5][6][10].

On the other hand, uranium was below MDA (0.25 Bq/kg) in all investigated samples due to the very low levels of uranium isotopes in investigated samples. Inductively coupled plasma mass spectrometry (ICP-MS) is known to be more precise and sensitive in measuring low level of radioactivity.

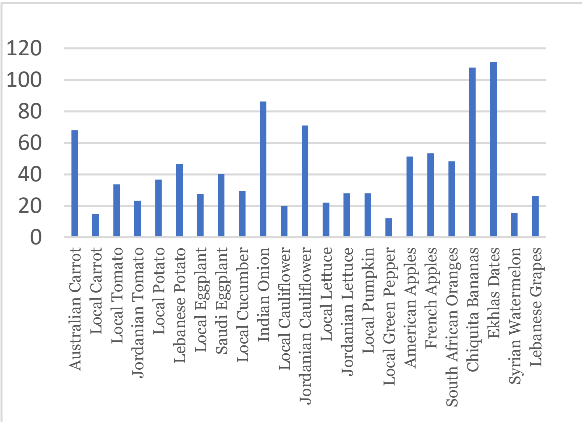


Figure 3. Polonium-210 activity concentration (mBq/kg) in most consumed fruits and vegetables in Kuwait

Table 1. Po -210 activity concentrations in fruits and vegetables from different regions

| Study | Activity concentration in wet samples |
|---|---|
| Current study | 12.1 to 111.4 mBq/kg |
| South India | 65 and 74 mBq/kg [4] |
| South Africa | 61 mBq/kg [5] |
| Australia | 20 to 100 mBq/kg [6] |
| Egypt | 140 ± 43 [10] |

## 4. Conclusion

Polonium-210 was monitored in all most consumed fruits and vegetables in Kuwait, while uranium radionuclides were below the detection limit. $^{210}$Po radioactivity levels in fruits and vegetables are comparable to other international data; thus, their consumption can be considered radiologically safe. The baseline generated data can be beneficial for the whole Gulf region due to similarities in eating habits and food sources. Further investigation for gamma emitters in fruits and vegetables will be carried out.

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## References

1. *Natural and induced radioactivity in food*, IAEA-TECDOC-1287, IAEA, Vienna, Austria, 2002.
Retrieved from:
https://www.iaea.org/publications/6291/natural-and-induced-radioactivity-in-food
Retrieved on: Sep. 17, 2022
2. F. Carvalho et al., *The Environmental Behaviour of Polonium*, Tech. Rep. Series no. 484, IAEA, Vienna, Austria, 2017.
Retrieved from:
https://www.iaea.org/publications/10845/the-environmental-behaviour-of-polonium
Retrieved on: Sep. 17, 2022
3. J. Alexander et al., "Uranium in foodstuffs, in particular mineral water," *EFSA J.*, vol. 7, no. 4, 1018, Apr. 2009.
DOI: 10.2903/j.efsa.2009.1018
4. K. D. Arunachalam et al., "Ingestion of Polonium ($^{210}$Po) via dietary sources in high background radiation areas of south India," *Int. J. Radiat. Biol.*, vol. 90, no. 10, pp. 867 – 875, Oct. 2014.
DOI: 10.3109/09553002.2014.922720
PMid: 24844373
5. I. Louw, A. Faanhof, D. Kotze, "Determination of Polonium-210 in various foodstuffs after microwave digestion," *Radioprotection*, vol. 44, no. 5, pp. 89 – 95, 2009.
DOI: 10.1051/radiopro/20095022
6. S. Sdraulig, B. Orr, D. Urban, R. Tinker, *Radiation doses from the average Australian diet*, Tech. Rep. 181, ARPANSA, Melbourne, Australia, 2019.
Retrieved from:
https://www.arpansa.gov.au/sites/default/files/tr181.pdf
Retrieved on: Sep. 17, 2022
7. L. Zikovsky, "Determination of uranium in food in Quebec by neutron activation analysis," *J. Radioanal. Nucl. Chem.*, vol. 267, no. 3, pp. 695 – 697, Mar. 2006.
DOI: 10.1007/s10967-006-0106-9
8. F. Monroy-Guzmán, "Isolation of uranium by anionic exchange resins," *J. Chem. Chem. Eng.*, vol. 10, no. 2, pp. 90 – 95, 2016.
DOI: 10.17265/1934-7375/2016.02.005
9. *A Procedure for Determination of Po-210 in Water Samples by Alpha Spectrometry*, IAEA/AQ/12, IAEA, Vienna, Austria, 2010.
Retrieved from:
https://www.iaea.org/publications/8200/a-procedure-for-determination-of-po-210-in-water-samples-by-alpha-spectrometry
Retrieved on: Sep. 17, 2022
10. K. S. Din, "Determination of 210Po in various foodstuffs and its annual effective dose to inhabitants of Qena City, Egypt," *Sci. Total Environ.*, 2011, vol. 409, no. 24, pp. 5301 – 5304, Nov. 2011.
DOI: 10.1016/j.scitotenv.2011.09.001
PMid: 21959247