*Research Journal of Recent Sciences* _____ E-ISSN 2277-2502
Vol. **5(12),** 10-16, December **(2016)** *Res. J. Recent Sci.*

# Investigation of Radioactivity level in some Non-Food items Imported to Sudan

**Haitham M. Elhassan[1,2*], Mustafa M.O. Ahamed[3], Isam Salih[3] and Hajo Idriss[3]**
[1]Sudan Academy of Sciences
[2]Radiation Protection and Nuclear Security Unit, Sudan Customs, Ministry of Interior, Khartoum, Sudan
[3]Sudan Atomic Energy Commission,
haitham12622@yahoo.com

**Available online at: www.isca.in, www.isca.me**
Received 14th November 2016, revised 30th November 2016, accepted 2nd December 2016

## Abstract

*Environmental monitoring for radioactivity is very important in view of radiation protection and environmental security. Hence, an investigation has been performed to quantify radioactivity level in some non-food items imported to Sudan. Radioactivity was measured by using high-resolution γ-spectroscopy based on HPGe detector. The survey has resulted in detection of radionuclides $^{134}Cs$, $^{137}Cs$, $^{40}K$, $^{226}Ra$, and $^{60}Co$. The result of this investigation has revealed that some imported substances contain high activity concentration. However, the obtained result have shown that the $^{134}Cs$, $^{137}Cs$, $^{40}K$, $^{226}Ra$, and $^{60}Co$ activity concentration were far below the limit proposed (CODEX). In the Sudan, there is no standard limit for radionuclides concentrations in some imported substances. Therefore, we need to set a national standard limit for some radionuclide in imported substance and laying down under a legal framework.*

**Keywords:** HPGe detector**,** chemicals samples, $^{134}Cs$, $^{137}Cs$, $^{40}K$, $^{226}Ra$, and $^{60}Co$

## Introduction

Human beings and other organisms are continually exposed to natural radiation caused by the radioactive elements which are found in food, feed, and drinking water[1-3]. In addition, they receive the radiation from anthropogenic radionuclide that might be released to the environment as result of normal and abnormal practice[4]. Contamination of animal products (meat, milk) takes place by contaminated pasture[5]. Aquatic group and fishes are polluted directly as a consequence of radioactivity in surface water[6].

There are a number of nuclear accidents led to the spread of anthropogenic radionuclides in the environment, leading to possible health risks and disturbance of the global food market: above ground atomic bomb tests in the 1950s and 1960s, the Chernobyl disaster in 1986 and the Fukushima disaster in 2011[7-9]. Following an investigation after the Chernobyl event, the International Atomic Energy Agency determined which radioactive elements released through nuclear events may be considerable for the food chain[10]. According to literature survey about 3.8 × 1016 Bq of 137Cs was released into the environment due to Chernobyl disaster[11]. Nowadays most of the countries around the world have continuous radioactivity monitoring programs for the purpose of radiation protection and public health care with emphasize on radioactivity in food stuff, soil and other industrial product[12-17]. This work is part of nationwide programme to quantify radioactivity with the aim of building up abroad database on radioactivity level in imported materials.

## Materials and Methods

**Samples collection:** A total of 43 non-food samples (raw materials, powdered materials, fertilizers and miscells) were collected from the customs and transported in plastic bags to the radiation protection and nuclear security laboratory at Khartoum airport for preparation and radioactivity measurement. The Samples were measured without further treatment.

**Gamma spectroscopic analysis:** The activities of $^{134}Cs$, $^{137}Cs$, $^{40}K$, $^{226}Ra$ and $^{60}Co$ were determined by gamma-ray spectrometric measurements for 6 hours. The measurements were conducted using HPGe detector (Ortec-efficiency 40%, energy resolution 1.8 keV at 1332.5 keV). Energy and efficiency calibration of the system has been performed using as a set of standards obtained from International Atomic Energy Agency (IAEA). The spectral analysis was performed with the aid of computer software maestro software obtained from Ortec. 226Ra was determined via energy line of 214Bi (609 keV) and $^{214}Pb$ (352 keV), while the activity of $^{60}Co$ was determined via energy line of 1332 kev. The activities of 40K, 134Cs and 137Cs were determined from its energy lines of 1460, 604 and 661 keV, respectively.

## Results and Discussion

A total of 43 different types of some non-food were analyzed in this study to quantify radioactivity concentration. The survey has resulted in detection of radionuclides $^{134}Cs$, $^{137}Cs$, $^{40}K$, $^{226}Ra$ and $^{60}Co$ as shown in the Table-1. Descriptive statistics of the

investigated radionuclides $^{134}$Cs, $^{137}$Cs, $^{40}$K, $^{226}$Ra and $^{60}$Co activity concentration in Bq/kg are presented in Table-2.

Figure-1 present the $^{134}$Cs activity concentration in the investigated samples, $^{134}$Cs was detected in 40 samples out of 43, and was found in a range of 00.08–0.45 Bq/kg with a median value of 0.38 Bq/kg. $^{137}$Cs was detected in all analyzed samples as shown in Figure-1 and ranged from 0.07 – 54.00 mg/kg and with a median value of 0.45 Bq/kg. Generally, there was a huge release of artificial radionuclides $^{134}$Cs and $^{137}$Cs to the atmosphere during the Chernobyl and the Fukushima disaster due to fallout activity[18-19], $^{40}$K was found in all samples with range of 125.12– 10580.10 Bq/kg and the median value of 7005.55 Bq/kg as shown in Figure-3. $^{60}$Co was detected in 5 samples out of 43, on the other hand, $^{226}$Ra was measured in 3 samples out of 43 as presents in a Table-1. $^{60}$Co is a synthetic radioactive isotope of cobalt with a half-life of 5.2714 years. It is produced artificially in nuclear reactors[20]. The result of this investigation has revealed that some imported substances contain high activity concentration. However, the obtained result have shown that the $^{134}$Cs, $^{137}$Cs, $^{40}$K, $^{226}$Ra, and $^{60}$Co activity concentration were far below the limit proposed by CODEX. In the Sudan, there is no standard limit for radionuclides concentrations in some imported substances. There are some countries set local standards limit of the radioactivity level in imported substances[22-23]. Therefore, we need to set a national standard limit of some radionuclide and bring under regulatory control.

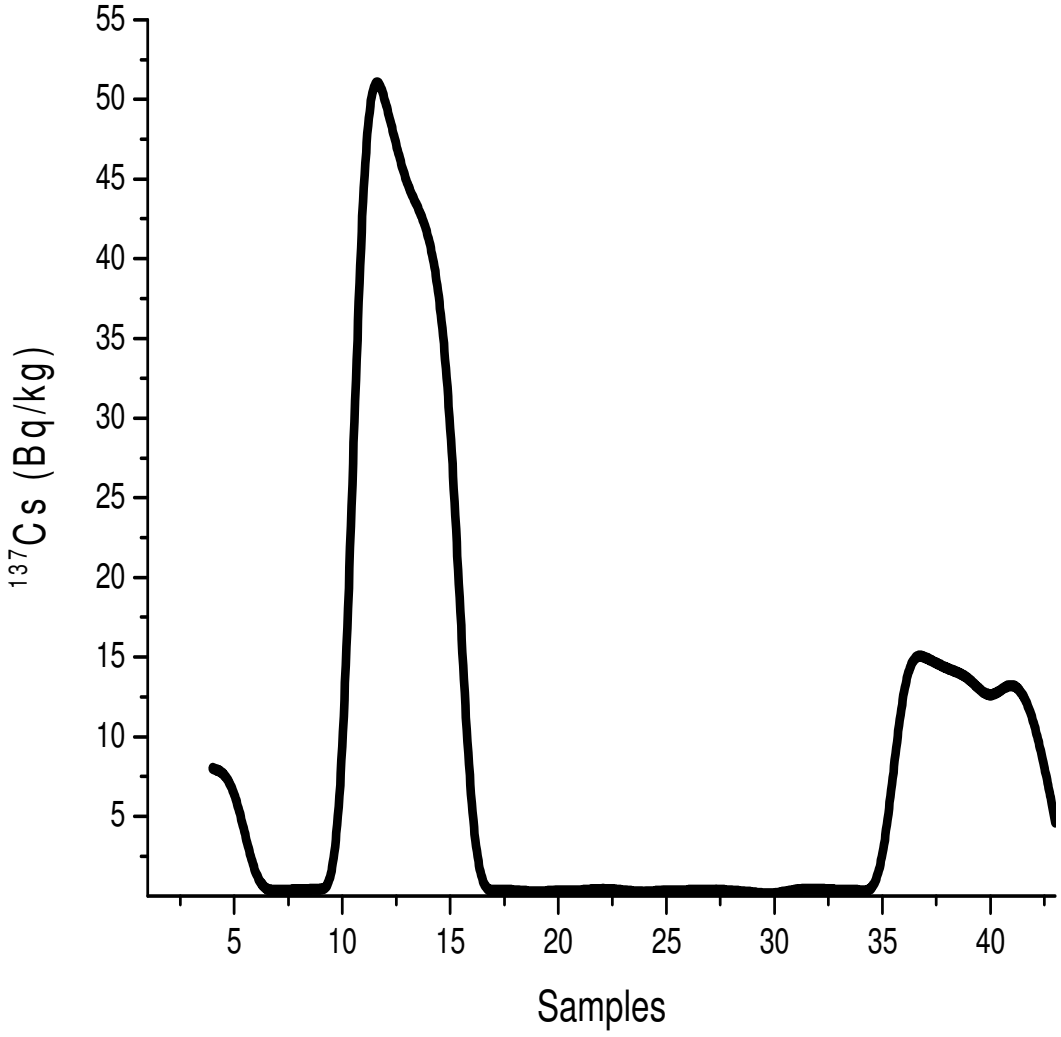


**Figure-1**
**$^{134}$Cs activity concentration in samples**

**Table-1**
**Activity concentration of 134Cs, 137Cs, 40K, 226Ra, and 60Co Bq/kg in non-food items**

| Samples No | $^{134}$Cs | $^{137}$Cs | $^{40}$K | $^{60}$Co | $^{226}$Ra |
|---|---|---|---|---|---|
| 1 | 0.30 | 9.12 | 5990.10 | 50.5 | - |
| 2 | 0.31 | 8.90 | 5800.10 | 50.15 | - |
| 3 | 0.35 | 8.29 | 5862.45 | 49.99 | - |
| 4 | 0.45 | 8.01 | 4890.25 | 40.58 | - |
| 5 | 0.45 | 7.50 | 1970.12 | 23.33 | - |
| 6 | 0.20 | 0.25 | 8150.30 | - | - |
| 7 | 0.30 | 0.39 | 8100.03 | - | - |
| 8 | 0.35 | 0.35 | 7980.10 | - | - |
| 9 | 0.40 | 0.45 | 6050.50 | - | - |
| 10 | 0.45 | 0.45 | 2005.00 | - | - |
| 11 | 0.30 | 54.00 | 10580.10 | - | - |
| 12 | 0.25 | 50.25 | 10524.68 | - | - |
| 13 | 0.35 | 44.00 | 9862.50 | - | - |
| 14 | 0.40 | 42.54 | 9050.20 | - | - |
| 15 | 0.35 | 33.30 | 7070.10 | - | - |
| 16 | 0.42 | 0.30 | 7600.55 | - | - |
| 17 | 0.25 | 0.35 | 7672.94 | - | - |
| 18 | 0.45 | 0.35 | 7076.00 | - | - |
| 19 | 0.40 | 0.20 | 5060.50 | - | - |
| 20 | 0.44 | 0.37 | 3312.20 | - | - |
| 21 | 0.42 | 0.30 | 8100.20 | - | - |
| 22 | 0.20 | 0.45 | 8149.03 | - | - |
| 23 | 0.41 | 0.33 | 7005.55 | - | - |
| 24 | 0.09 | 0.20 | 6656.02 | - | - |
| 25 | 0.45 | 0.37 | 4050.00 | - | - |

| **Samples No** | **$^{134}$Cs** | **$^{137}$Cs** | **$^{40}$K** | **$^{60}$Co** | **$^{226}$Ra** |
|---|---|---|---|---|---|
| 26 | 0.40 | 0.33 | 7110.00 | - | - |
| 27 | 0.25 | 0.40 | 7150.03 | - | - |
| 28 | 0.41 | 0.33 | 6090.90 | - | - |
| 29 | 0.08 | 0.20 | 4405.22 | - | - |
| 30 | 0.45 | 0.07 | 2200.10 | - | - |
| 31 | 0.45 | 0.43 | 7120.00 | - | - |
| 32 | 0.28 | 0.45 | 7150.03 | - | - |
| 33 | 0.41 | 0.33 | 6500.90 | - | - |
| 34 | 0.09 | 0.40 | 4005.22 | - | - |
| 35 | 0.45 | 0.07 | 3305.50 | - | - |
| 36 | 0.10 | 15.50 | 1008.11 | - | - |
| 37 | 0.40 | 15.00 | 9550.23 | - | - |
| 38 | 0.42 | 14.22 | 9161.89 | - | - |
| 39 | 0.35 | 13.85 | 8860.55 | - | - |
| 40 | 0.32 | 12.00 | 7560.16 | - | - |
| 41 | - | 13.92 | 233.34 | - | 37.04 |
| 42 | - | 11.61 | 266.58 | - | 33.93 |
| 43 | - | 4.64 | 125.12 | - | 3.50 |

**Table-**2
**Descriptive statistics of $^{134}$Cs, $^{137}$Cs, $^{40}$K, $^{226}$Ra, and $^{60}$Co activity concentration of in Bq/kg in non-food items**

| **Descriptive statistics** | **$^{134}$Cs** | **$^{137}$Cs** | **$^{40}$K** | **$^{60}$Co** | **$^{226}$Ra** |
|---|---|---|---|---|---|
| Min | 0.08 | 0.07 | 125.12 | 23.33 | 3.50 |
| Max | 0.45 | 54.00 | 10580.10 | 50.50 | 37.04 |
| Average | 0.34 | 8.72 | 6055.20 | 42.91 | 24.82 |
| Std | 0.11 | 14.42 | 2821.79 | 14.02 | 16.92 |
| Median | 0.38 | 0.45 | 7005.55 | 49.99 | 33.93 |
| Geometric mean | 0.31 | 1.56 | 4640.50 | 41.28 | 16.38 |

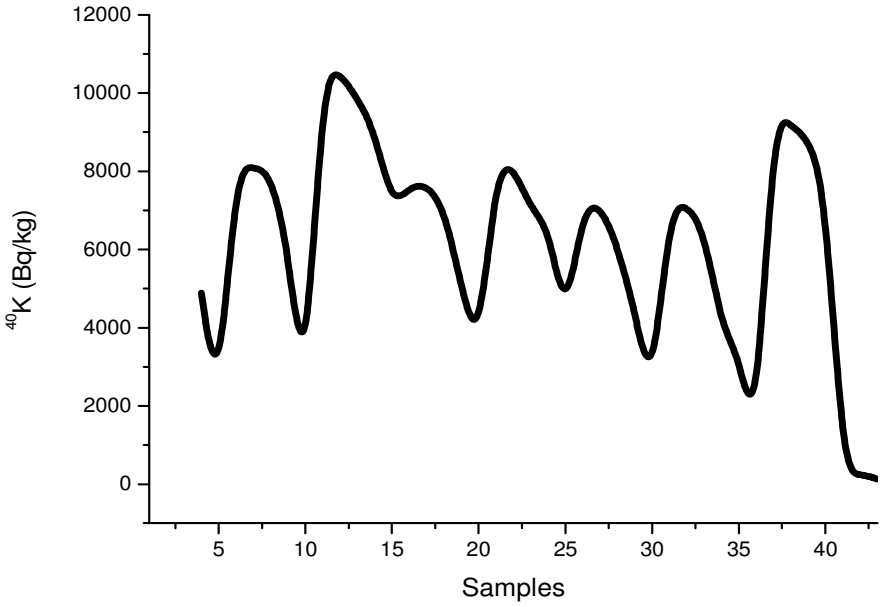


**Figure-2**
**$^{137}$Cs activity concentration in samples**

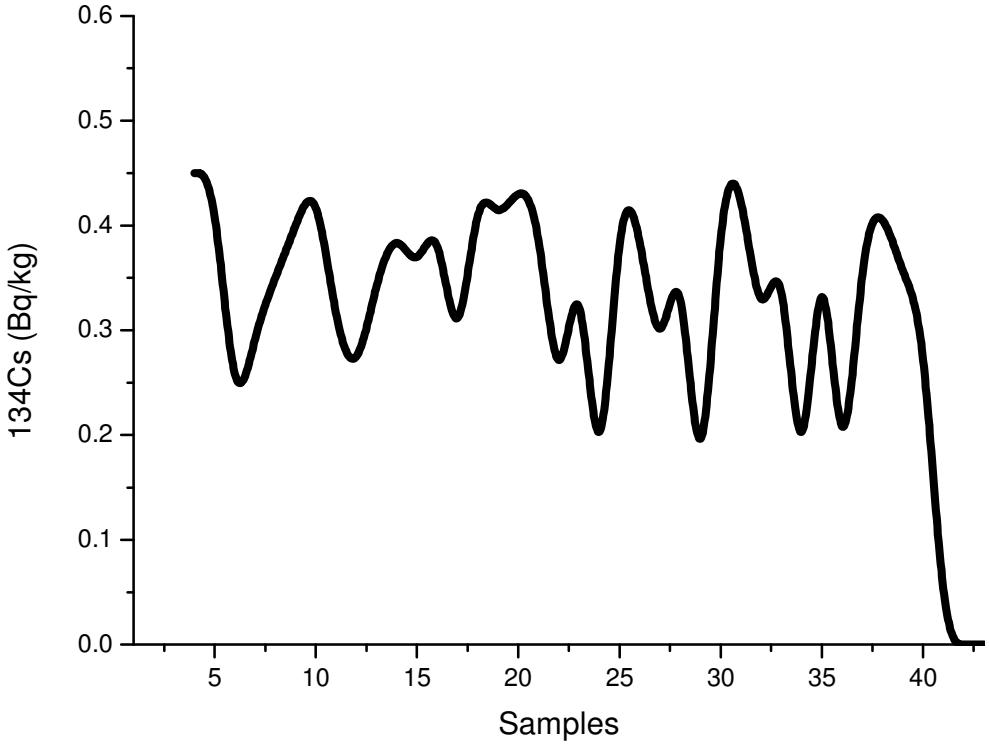


**Figure-**3
**$^{40}$K activity concentration in samples**

## Conclusion

The result of this investigation has revealed that some imported substances contain high activity concentration. However, The values of $^{134}Cs$, $^{137}Cs$, $^{40}K$, $^{226}Ra$ and $^{60}Co$ in the obtained results were far below the limit proposed by (CODEX).In the Sudan, there is no standard limit for radionuclides in some imported substances. Therefore, we need to set a national standard limit for some radionuclide in imported substance and laying down under a legal framework.

## Acknowledgment

The authors are extremely grateful to the staff of the Sudan Atomic Energy Commission for their kind assistance in samples analysis. Our sincere thanks are also extended to the Department of Radiation Protection and Nuclear Security unit - Customs.

## References

**1.** Idriss H., Salih I., Alaamer A.S., Saleh A. and Abdelgali M.Y. (2016). Environmental-Impact Assessment of Natural Radioactivity Around a Traditional Mining Area in Al-Ibedia, Sudan. *Archives of environmental contamination and toxicology*, 70(4), 783-792.

**2.** Kh A., Khandaker M.U., Amin Y.M. and Mahat R. (2015). Uptake and distribution of natural radioactivity in rice from soil in northand west part of peninsular Malaysia for the estimation of ingestion dose to man. *Ann Nucl Energy,* 76, 85-93.

**3.** Shanthi G., Kumaran J.T.T., Raj G.A.G. and Maniyan C.G. (2010). Natural radionuclides in the South Indian foods and their annual dose. Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, 619(1), 436-440.

**4.** Sam A.K., Ahamed M.M.O., El Khangi F.A., El Nigumi Y.O. and Holm E. (1998). Radioactivity levels in the Red Sea coastal environment of Sudan. Marine Pollution Bulletin, 36(1), 19-26.

**5.** Douka C.E. and Xenoulis A.C. (1991). Radioactive isotope uptake in a grass-legume association. *Environmental pollution*, 73(1), 11-23.

**6.** Hassona R.K., Sam A.K., Osman O.I., Sirelkhatim D.A. and LaRosa J. (2008). Assessment of Committed Effective Dose due to consumption of Red Sea coral reef fishes collected from the local market (Sudan). *Science of the Total Environment*, 393(2), 214-218.

**7.** Glavič–Cindro D., Benedik L., Logar J.K., Vodenik B. and Zorko B. (2013). Detection of Fukushima plume within regular Slovenian environmental radioactivity surveillance. *Applied Radiation and Isotopes*, 81, 374-378.

**8.** Wätjen U., Spasova Y. and Altzitzoglou T. (2008). Measurement comparisons of radioactivity among European monitoring laboratories for the environment and food stuff. *Applied Radiation and Isotopes*, 66(6), 742-749.

**9.** Meli M.A., Desideri D., Roselli C., Feduzi L. and Benedetti C. (2016). Radioactivity in honey of the central Italy. *Food chemistry*, 202, 349-355.

**10.** Şahin N.K., Yeltepe E. and Yücel Ü. (2016). A review of the nationwide proficiency test on natural radioactivity measurements by gamma spectrometry. *Applied Radiation and Isotopes*, 109, 49-53.

**11.** Alaamer A.S. (2012). Characterization of 137 Cs in Riyadh Saudi Arabia Soil Samples.

**12.** Abukawa J., Tsubuku C., Hayano K. and Hirano K. (1998). A survey of 90 Sr and 137 Cs activity levels of retail foods in Japan. *Journal of environmental radioactivity*, 41(3), 287-305.

**13.** Changizi V., Shafiei E. and Zareh M.R. (2013). Measurement of 226Ra, 232Th, 137Cs and 40K activities of Wheat and Corn Products in Ilam Province–Iran and Resultant Annual Ingestion Radiation Dose. *Iranian journal of public health*, 42(8), 903.

**14.** Nain M., Chauhan R.P. and Chakarvarti S.K. (2008). Alpha radioactivity in tobacco leaves: Effect of fertilizers. *Radiation Measurements*, 43, S515-S519.

**15.** Sam A.K. and Abbas N. (2001). Assessment of radioactivity and the associated hazards in local and imported cement types used in Sudan. *Radiation protection dosimetry*, 93(3), 275-277.

**16.** Martell E.A. (1974). Radioactivity of tobacco trichomes and insoluble cigarette smoke particles. *Nature*, 249(5454), 214-217.

**17.** Ramachandran T.V. and Mishra U.C. (1989). Measurement of natural radioactivity levels in Indian foodstuffs by gamma spectrometry. *International Journal of Radiation Applications and Instrumentation. Part A. Applied Radiation and Isotopes,* 40(8), 723-726.

**18.** Mishra S., Arae H., Sorimachi A., Hosoda M., Tokonami S., Ishikawa T. and Sahoo S.K. (2015). Distribution and retention of Cs radioisotopes in soil affected by Fukushima nuclear plant accident. *Journal of Soils and Sediments*, 15(2), 374-380.

**19.** Al Hamarneh I., Wreikat A. and Toukan K. (2003). Radioactivity concentrations of 40 K, 134 Cs, 137 Cs, 90 Sr, 241 Am, 238 Pu and 239+ 240 Pu radionuclides in jordanian soil samples. *Journal of Environmental Radioactivity*, 67(1), 53-67.

**20.** Codex Alimentarius Commission (1995). Codex general standard for contaminants and toxins in food and feed. Codex stan, 193.

**21.** Baba M.M.H., Mohib-ul-Haq M. and Khan M.A.A. (2013). Dosimetric consistency of Co-60 teletherapy unit-a ten

years study. *International journal of health sciences*, *7*(1), 15.

**22.** Ghiassi-Nejad M., Beitollahi M.M., Fallahian N., Amidi J. and Ramezani H. (2001). Concentrations of natural radionuclides in imported mineral substances. *Environment international*, 26(7), 557-560.

**23.** Jankovi M.M. and Dragana J. (2011). Con Cen Tra Tions of Nat U Ral Radionuclides In Im Ported Zir Co Nium Min Er Als.