^{40}K levels in some commercially consumed food crops collected from some villages in Barkin Ladi LGA, Plateau State Nigeria

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Abstract

The specific activity concentrations and the derived Annual Effective Doses in food crops cultivated and consumed within and outside the study area were measured by using a multi-channel pulse analyzer (Canberra series 10 plus coupled to a 76mm x 76mmNaI(Tl) scintillation detector. The activity concentrations of ^{40}K ranged from 153.92 ± 5.28Bq/kg to 41.59 ± 6.60Bq/kg with a mean value of 111.27 ± 4.65Bq/kg. The annual Effective Dose was also calculated and the values ranged from 25.00μSvy^{-1} to 10.23μSvy^{-1} with an average of 14.69μSvy^{-1}. The discrepancies in the results might be attributed to geological factors such as soil formation, application of fertilizer and differences in the type of crops analyzed. Although the results obtained were within the standard limit and may not pose any health hazard.
***Keywords**: Potassium-40, Food crops, Isotopes, Activity, Annual effective dose and Nigeria*

Introduction

Potassium is an essential mineral for the growth of plants. From the health physics point of view, potassium is the largest contributor to the dose received by humans due to its wide spread distribution in the environment and living organisms (Al-Masri*et al*, 2004). Potassium being the 7th most abundant element makes up to 2.4% of the earth crust by weight but much of this potassium is not available in plants. It is a very reactive element and hardly found in free state. It can be obtained from minerals such as camallite ($Kcl.MgCl_2.6H_2O$) langbeinite ($K_2Mg(SO_2)_3$) and polyhalite ($K_2Ca_2Mg(SO_4)_4.2H_2O_2$). The yield of crops is directly related with the quantity of potassium present in the soil which can be achieved by the addition of NPK fertilizer. This is due to the presence of ^{40}K in NPK fertilizer as stated in the formula (Jwanbot*et al*, 2012).

Natural potassium is a combination of three isotopes ^{39}K, ^{40}K, and ^{41}K with mass percentage of 93.258%, 0.0117% and 6.702% respectively. The half live of ^{40}K is 1.3 billion years and it decay to ^{40}Ca by emitting a beta particle with no attendant gamma radiation (89% of the times) and the gas ^{40}Ar by electron capture with emission of an energetic gamma ray (11% of the times). The strong gamma radiation ($E\gamma$ = 1.46MeV) makes the external exposure to this radioisotope a concern.While in the body ^{40}K poses a health hazard from the beta particles ($E_{\beta max}$= 1.35MeV) and gamma rays which associate with cell damage and general potential for subsequent cancer induction (Esposito *et al*, 2002 and Cember, 1983).

The concentration of potassium as an essential element for the body is under homeostatic controls and one can find about 2g of this element in one Kg of the body mass which used to sustain biological process. With regards to the average natural abundance of ^{40}K, which is about 0.0117% and its transfer factor to the body, the normal average activity of these radionuclides in humans, eliminated from the body by a biological half-life of 30 days is reported as 60Bq/kg. The accumulated activity of this radioisotope in the body can cause absorb dose which ranges from 100μGy to 270μGy in the thyroid glands and bone marrow respectively (Cember, 1983 and UNCSEAR, 1988). Moreover in normal situation ^{40}K to a lesser extent and other dietary sources of primordial radionuclide produce an average effective dose rate of 400μSv/yr (40mrem/yr) or 13% of natural background radiation.

Being an area where the inhabitant are mostly farmers, crops such as maize, millet, guinea corn, carrots cabbage, pepper, green beans, garden egg, tomatoes and potatoes are cultivated in commercial quantity are grown in these areas.

The aim of this work is to determine the activity concentrations of ^{40}K in some food crops produce in some villages in BarkinLadi LGA of Plateau State.

Materials and Method

Crop samples which are produced in commercial quantity were collected from different location (villages) within the study area. The food crops include maize, carrot, yam, cocoa yam, cabbage, spinach, tomatoes, green beans and green pepper.

The samples were washed and peeled when necessary, dried naturally and weighed for the determination of humid mass. After wards they were dried in the oven for about 70 ^{0}C (Ibeanu, 2003) until they reached a constant weight. They were ground properly using a metal mortar for homogenization. The samples were sieved with a 300µm sieve About 200mg each of food samples was measured and encapsulated. The encapsulation material used for this work is polyethylene and the rabbit capsule used during encapsulation were cleaned by soaking 1:1 HNO_3 for three days and washed with de-iodized water. After crushing, the samples were weighed and carefully sealed to prevent gaseous escape and kept for 28 days for secular equilibrium of uranium and its progeny to be established. A large fraction of natural radiation exposure is due to ingestion of food containing natural radionuclides such as ^{40}K, ^{226}Ra, ^{210}Po and ^{210}Pb (Mc Donald, 1999). Among these , ^{40}K is the most important radionuclide from health physics and forms the largest contribution to the dose received by humans due to its wide spread distribution in the environment and living organisms (Al- Masri*et al*, 2004).

Results and Disscussion

Activity Concentrations of the Food Crop Samples

The activity concentration in food samples was obtained using the following expression.

$$c = \frac{c_n}{\varepsilon P_\gamma M_s} \qquad (1)$$

Where C (Bq/kg) is the activity concentrations of ^{40}K in the crop samples.C_n is the primary count rate under the photo peak which was calculated by the system, ε is the detector efficiency for the ^{40}K specific gamma ray, P_γ is the absolute transition probability of the ^{40}K specific gamma ray and M_s is the mass of the sample (kg).

Calculation of Annual Effective Dose.

The annual effective dose due to intake of natural radionuclides in foods can be calculated from the formula given by (Alam*et al*., 1999, and Zain*et al*, 2013).

$$D = C.\ I.\ E. \qquad (2)$$

Where D is the annual effective dose (Sv/yr) to an individual due to the ingestion of radionuclides C the activity concentration of radionuclides in the ingested sample (Bg/kg). I the annual intake of food crop sample which depends on a given age (ICRP, 1996) and E the ingested dose conversion factor for radionuclides (Sv/Bq).
The conversion factor "E" varies with both radioisotopes and the age of the individual are listed in table above (1) (Zain*et al*, 2013). The calculation are based on the assumption that each person takes food according to the consumption rate defined in the food balance sheet as reported by Makon (2011). In this study the average consumption is for adults (age from 17 and above)

The activity concentration of the crop samples were determined using equation (1). As stated in Table 2 cabbage and spinach showed high activity concentrations of ^{40}K with a value of 153.92Bq/kg and 144.30Bq/kg respectively. These results are also shown in Fig1. This may be attributed to the fact that these are leafy vegetables with big broad leaves which have two access points to potassium absorption (Ibrahim and whicker, 1988). The lowest activity concentration was found in yam with a value of 41.59Bq/kg. The average value of the activity concentration of the crop samples was found to be 111.27Bq/kg. This may be attributed to the fact that ^{40}K is an isotope of potassium (K) element, a macronutrient indispensible to plants. The average value of the levels analyzed is within the recommended value. The annual effective dose calculated from the food crops in the study area falls within the range of 10.30µSvy^{-1} to 25.00µSvy^{-1} as shown in Fig 2 giving an indication that the food crops within the study area will not be of any health hazard to the consumers of these crops.

Table.1: Dose Conversion Factors ^{40}K for the age groups of children (2-7yr, 7-12yr, 12-17yr) and adults (17yr and above). Zain*et al,* 2013

AGE	^{40}K
2-7yr	2.1×10-8
7-12yr	1.3×10-8
12-17yr	7.6×10-9
17yr and above	6.2×10-9

Table 2: Activity Concentrations of ^{40}K Bq/kg and Annual effective Dose(µSvy-1)

	Qty	Activity concentrations of ^{40}K Bq/kg	Annual effective dose (µSvy^{-1})
Cabbage	6	153.92±5.28	20.60
Garden egg	1	120.17±7.18	11.50
Tomatoes	4	75.40±4.66	15.72
Carrot	1	132.29±2.64	10.31
Maize	1	107.60±5.13	13.72
Cocoa yam	2	124.53±3.14	10.23
Green beans	1	122.40±2.64	14.68
Yam	1	41.59±6.60	10.82
Pepper	1	90.51±3.62	14.34
Spinach	2	144.27±5.59	25.00
Average		**111.27±4.65**	**14.69**

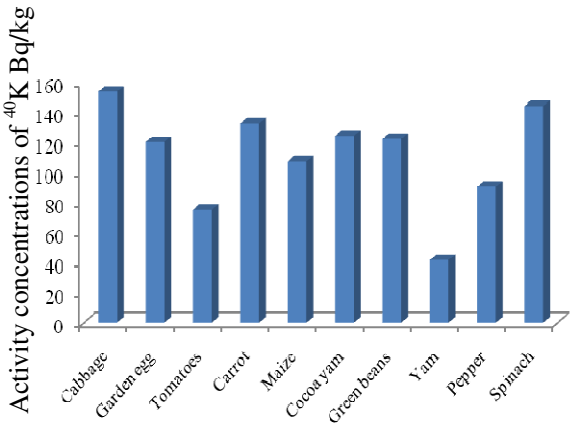

Figure 1: Activity concentrations of ^{40}K Bq/kg

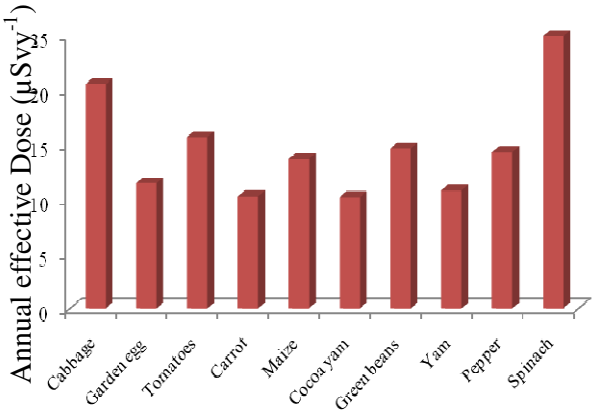

Figure 2: Annual effective Dose (µSvy^{-1})

Conclusion

Potassium-40 in the environment behaves the same as other potassium isotopes, being assimilated into tissues of all plants and animals through normal biological processes. Ingestion of the contaminated food is one of the routes of uptake of potentially dangerous radionuclides for man and potassium was chosen because of its out most importance. This radionuclide is one of the most important long lived radionuclide on earth crust and its concentration in environmental samples can be an indication for long-term radiation of this element because of its high solubility and ease of transfer. The data acquired also provided an opportunity to verity any impact from the ingestion of this radionuclide in the living organisms, including humans. Considering the health physics limitations, the amount of the average effective dose calculated in this area is given as 14.68µSvy^{-1} for adults. This showed that the dose received by the ingestion of this crop is low to induce health hazard. Finally, although the investigation showed no significant hazard, the data obtained was so useful for monitoring programs in particular situations such as uncontrolled use of fertilizers and other human manipulations in the environment; since together with nitrogen and phosphorous potassium is a major soil fertilizer and levels of ^{40}K in soils are strongly influenced by fertilizer application.

References

Alam M.N., Chowdhury, M.I., Kamal M., Ghose S., Islam M. N. and Anwaruddin M. (1999): Radiological Assessment of drinking water of the Chittagong region of Bangladesh. *Radiat. Prot. Dosim*. **82**, 207-214.

Al-Masri MS, Mukallati H, Al-Hamwi A, Khalili H, Hassan M, Assaf H, Amin Y, Nashawati A (2004): Natural radionuclides in Syrian diet and their daily intake. *J RadioanalNucl.Chem,***260:**405-412.

Cember H (1983): Introduction to Health Physics. 2nd Ed Pergamon press. New York, USA, 79-87.

Esposito M, Polic P, Bartolomei P, Benzi V (2002): Survey of natural and anthropogenic in radioactivity in environmental sample from Yugoslavia. *J Environ Radioactivity, **61*:** 271-282.

Ibeanu G.E. (2003): Tin Mining and processing in Nigeria: Cause for concern **64**, 59-66.

Ibrahim, S.A and Whicker F.W. (1988): Comparative uptake of U and Th by native plants at a U production site. *Health Physics***54** (4)413

ICRP (1996): Age-dependent doses to members of the public from intake of radionuclides: Part 5 compilation of ingestion and inhalation dose co-efficient. *ICRP Pub* No 72, Pergamon press, Oxford.

Jwanbot D.I., Izam M.M. and Nyam G.G, (2012): Radioactivity in some food crops from high background radiation area from the Jos-Plateau, Nigeria. *Journal of Natural Science Research* **2**(6), 76-78.

Makon T.B, Robert M. N., and Tchokossa P., (2011): Investigation of Gamma – Emitting Natural Radioactive Contents in three types of Veronia consumed in Cameroon. *World Journal of Nuclear Science and Technology,***1**, 37-45.

Mc Donald P, Jackson D, and Leonard DRP, Mckay K (1999): An assessment of ^{210}Pband ^{210}Po terrestrial food stuffs from regions of potential technological enhancement in England and Wales. *J Environ Radioactivity,* **43:** 15-29.

UNSCEAR (1988):Sources,effects and risks of ionizing radiation.United Nations Committee on the effects of atomic radiation New York,95-96.

Zain M.A. (2013): Assessment of Natural Radionuclides in powdered milk consumed in Saudi Arabia and the Estimation of the Annual Effective Dose. *Journal of American Science,* **9** (6), 267-273.