Estimation of Carcinogenic Risk Through Ingestion of Locally Available Food Materials of South West Coast of India

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http://dx.doi.org/10.22147/jusps-A/300111

Acceptance Date 21st December, 2017, Online Publication Date 2nd January, 2018

Abstract

Primordial radionuclide in human habitats has always been a source of prolonged exposure. These can be transferred to humans through food chain. The assessment of intake of radionuclide through food is based on the activity concentration of the radio-isotopes in food and their average intake rate. The Life time cancer risk (LCR) is estimated due to the ingestion of commonly used food items of south west coast of Kerala as proposed by USEPA. The estimated carcinogenic risk due to commonly used food items is 3.39x10⁻³ and that due to whole meal is 2.77x10⁻³, which are in good agreement with the acceptable limits.

Key words : Primordial radionuclides, Life time cancer risk, Gamma ray spectrometry.

Introduction

Radioactivity is present in the air we breathe, the food we eat, and the dwellings we live in. Humans are exposed to environmental radiation through inhalation of dusts (contaminated with radiation) and gases, ingestion of dusts, soils, water, vegetation or meat and absorption of direct radiation from radioactive sources.¹ Radionuclides can be transferred to humans through the food chain. Bioaccumulation of radionuclides by plants is a well known phenomenon. Plants may get radioactive nuclides in two ways (i) by absorption from the soil and (ii) by the deposition of radiation fall out on the leaves directly. The radioactivity content of the

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food crops from high background radiation area was higher when compared to similar samples collected from low-background radiation area. The south west coastal region of India is known as a High Background Radiation Area (HBRA) owing to the presence of thorium rich monazite sand available in abundance in the region\(^2\). It was estimated that a larger portion of at least one-eighth of the mean annual effective dose due to natural sources can be attributed to the uptake of food. This can result in an increase in population radiation doses, which requires an understanding of the environmental behaviors of different radionuclides and estimation of their human risks. Regardless the pathways of transfer, once radionuclides are housed inside the body, the cells, the tissues, and the host organs are constantly exposed by their emitted energetic and particulate forms of radiations. Based on the amount of received and/or exposed energy, the exposed cell may damage, the structure of exposed DNA may change, and finally many unwanted biological effects may occur\(^3\). In this work life time cancer risk due to the ingestion of locally available food materials of south west coast of Kerala is calculated. The calculation was done as proposed by the United States Environmental Protection Agency,(USEPA-1999)\(^4\).

**Experimental Procedure:**

Sample collection was based on a dietary habit survey conducted in the region among the people living in the region. 156 samples of 53 varieties of food items were collected from the coastal belt. The samples include cereals, pulses, grains, tubers, vegetables, tea powder, coffee powder, marine food samples and full meals. Also gross gamma dose rates in the locations were recorded with a gamma dosimeter.

For collection, preparation and analysis of the samples we have followed IAEA Guidelines (Measurement of Radionuclides in Food and the Environment, IAEA, 1989). Fresh samples collected from the farms were washed and the edible parts were separated. Wet weight of each sample was noted. Samples were dried under an IR lamp for 24 hours and then in a hot air oven at 110\(^0\)C for 24 hours. The weights of the dried samples were noted. Dried samples were powdered using a grinder and sieved to get homogenized sample. To ash the samples, these samples were further fired at about 300-320\(^0\)C in a muffle furnace. Ashed samples were then transferred to clean empty cylindrical plastic containers of specific size and were hermetically sealed. The samples were shelved for six weeks before gamma spectrometry analysis.

Analysis of the sample for determining the levels of \(^{238}\text{U}\), \(^{232}\text{Th}\) and \(^{40}\text{K}\) were done using a 5"×4" NaI(Tl) detector based on Gamma ray spectrometry. The detector is housed in a 3" thick graded lead shield and PC coupled 8 K MCA. The measurement procedure includes energy calibration, sensitivity calibration and gamma-ray analysis. The energy calibration was carried out by two radioactive calibration sources, \(^{137}\text{Cs}\) and \(^{57}\text{Co}\). The sensitivity calibration was achieved by using three artificial standard sources of \(^{238}\text{U}\), \(^{232}\text{Th}\) and \(^{40}\text{K}\). The activity of \(^{40}\text{K}\) was evaluated from the 1460 keV photo peak of its own gamma, the activity of \(^{238}\text{U}\) from 1764 keV gamma ray of \(^{214}\text{Bi}\) and that of \(^{232}\text{Th}\) from 2614 keV gamma ray of \(^{208}\text{Tl}\). The counting times of sample were 60000s for obtaining the net activity. Selecting the respective peaks for the isotopes, the regions of interest (ROI) were selected and the corresponding gross counts were noted. The contribution of background was deducted from the gross counts and the net activity was determined. The specific activities of the samples were determined using the wet weight of the samples.

An effort was made to assess the life time cancer risk (LCR) due to the ingestion of commonly used food items as proposed by the United States Environmental Protection Agency, USEPA 1999. The assessment of intake of radionuclide through food is based on the activity concentration of the radio-isotopes in food and their average intake rate. The following equation was used to calculate the mortality cancer risk.\(^5,6\)

\[
\text{LCR} = A_a \times A_b \times R_c 
\]

Where LCR, \(A_a\), \(A_b\) and \(R_c\) are the lifetime cancer risk, annual intake of radionuclide (Bq), average span of life (70 y) and mortality risk coefficient (Bq\(^{-1}\)), respectively.
The values of mortality cancer risk coefficients used in the calculation of LCR were $9.56 \times 10^{-9} \text{(Bq}^{-1})$ for $^{226}\text{Ra}$, $2.45 \times 10^{-9} \text{(Bq}^{-1})$ for $^{232}\text{Th}$ and $5.89 \times 10^{-10} \text{(Bq}^{-1})$ for $^{40}\text{K}$ as suggested by USEPA 1999.

**Results and Discussion**

The levels of radionuclides, the average intake rate of different food items and the life time cancer risk assessment is shown in the Table 1.

| Sample                  | Average level (Bq kg$^{-1}$) | Intake rate I (kg y$^{-1}$) | Life time risk LCR x10$^6$ | Total Life time Risk x10$^3$ |
|-------------------------|-----------------------------|-----------------------------|---------------------------|----------------------------|
|                         | $C_{\text{th}}$ | $C_{\text{U}}$ | $C_{\text{K}}$ |                                                                 |
| Leafy vegetables        | $20\pm4$       | $2.4\pm0.3$    | $436\pm20$   | $12\pm6$                                                | $150\pm32$                                            |
| Non leafy vegetables    | $17\pm4$       | $2.4\pm0.3$    | $75\pm8$     | $48\pm28$                                                | $279\pm64$                                            |
| Tubers                  | $20\pm4$       | $2.4\pm0.3$    | $314\pm18$   | $34\pm14$                                                | $354\pm50$                                            |
| Fruits                  | $16\pm4$       | $2.4\pm0.3$    | $724\pm27$   | $19\pm9$                                                 | $321\pm48$                                            |
| Rice                    | $19\pm4$       | $2.4\pm0.3$    | $64\pm8$     | $98\pm26$                                                | $584\pm98$                                            |
| Wheat                   | $18\pm4$       | $2.4\pm0.3$    | $187\pm13$   | $60\pm24$                                                | $474\pm74$                                            |
| Grains                  | $23\pm5$       | $2.4\pm0.3$    | $320\pm18$   | $28\pm18$                                                | $397\pm52$                                            |
| Tea                     | $31\pm6$       | $2.4\pm0.3$    | $386\pm19$   | $18\pm4$                                                 | $244\pm54$                                            |
| Coffee                  | $34\pm6$       | $2.4\pm0.3$    | $482\pm22$   | $10\pm6$                                                 | $158\pm33$                                            |
| Fish                    | $17\pm4$       | $2.4\pm0.3$    | $102\pm10$   | $68\pm26$                                                | $426\pm73$                                            |
| *Meals                  | $17\pm4$       | $2.4\pm0.3$    | $272\pm16$   | $447\pm74$                                               | $2768\pm342$                                          |

The levels of $^{232}\text{Th}$ and $^{40}\text{K}$ in grains and some edible items were shown in figure 1 and figure 2.
Analysis of locally available food samples using gamma spectrometry analysis in the experimental area indicate that in all samples uranium level was below detectable level of 4.7 Bq kg\(^{-1}\).

It has been seen that the annual intake estimates we arrived at are in good correlation with the dietary habit data given by UNSCEAR\(^7\), 2013 Report. From the analysis of spectrometry results, it can be inferred that activity of heavy radioactive elements, namely \(^{238}\)U and \(^{232}\)Th, are quite small (\(^{238}\)U levels are below detectable) while \(^{40}\)K is found at a higher level. Activity levels of \(^{238}\)U is assumed to be the half of the minimum detectable level of uranium(taken as 2.4 Bq kg\(^{-1}\))of the counting system, is presented in table-1.

**Conclusion**

Food safety is a major public health concern and the importance of the association with consumption of foodstuffs contaminated by heavy metals has increased worldwide\(^8\). The estimated excess life time cancer risk due to the ingestion of radionuclides through individual common food stuff was found to be \((3.39\pm0.58)\times10^{-3}\) and that from the whole meal alone was \((2.77\pm0.34)\times10^{-3}\). It is worth mentioning that the estimates are only from the primordial radionuclides present in food stuffs and other radionuclides, especially the Technologically Enhanced Naturally Occurring Radioactive Materials (TENORM) which contribute to the total dose are not taken into account.

The estimated values commensurate with the acceptable limits, they are slightly higher as compared to other areas in the world having thorium rich monazite sand\(^9\). So it causes no significant health hazard to public health in terms of the cancer risk.

**Acknowledgment**

This article and the work done was a part of the research project funded by the Board of Research in Nuclear Sciences Research Project No.2008/36/86-BRNS/2895 carried out at CARPS(Centre for Advanced Research in Physical Sciences), Research Department of Physics, Fatima Mata National College (Autonomous), Kollam. For their cooperation during the field work, we thankfully acknowledge the people living in the study area.
area.

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