Concentration Factor of Radionuclide in Food Crops from the South West Coast of Kerala

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ABSTRACT

Ubiquitous radiation has ever been a source of health concern to human beings. The primordial radionuclides in the biosphere are the main source of radiation exposure. Risks to human beings majorly depend on the accumulation of the radionuclides in food products. The southwest coastal region of India is a known high background radiation area (HBRA) owing to the presence of thorium rich monazites sand available in abundance. A systematic radiological survey has been carried out in the region of high-background radiation area in Kollam district of Kerala. 12 varieties of 75 food items which consists of vegetables, fruits, tubers and cereals available in different parts of coastal region of Kollam district in Kerala were collected as per standard sampling procedure. The levels of natural primordial radionuclides, namely radium, thorium and potassium were determined using Gamma ray spectrometry. The concentration factor is slightly higher in tubers and leafy vegetables. The uptake factor for potassium is found to be uniformly high in all the vegetables. Transfer Factor of radium in leafy vegetable, spinach was found higher when compare with other commonly consumed vegetables.

Keywords*-radionuclides, radiation, gamma ray*

INTRODUCTION

Radio-isotopes, both naturally occurring and technologically driven, works their way through the ecosystem. Radionuclides released to the environment from different sources may enter the atmosphere, surface water or groundwater. They are also transferred to the ecosystem through geophysical processes that slowly recycle the crustal matter to the biosphere. After release to the atmosphere, deposed radionuclides may contaminate soil, agricultural crops and plants and surface water. The levels of contamination may vary greatly from one area to another.

Certain regions on earth have higher levels of primordial radio nuclides occurring naturally. The south west coastal region of India is known as a High Background Radiation Area (HBRA) owing to the presence of thorium 8-10% monazite sand available in abundance in the region. Therefore, the population of the region has always been a centre of interest for the

ISSN:0971-1260
Vol-22- Issue-14-December-2019

researchers. Epidemiological studies on the population residing in the HBRA in Kerala is of considerable interest from the point of view of the understanding the effects of low and chronic radiation exposures on the health of human population. Several agencies have carried out coordinated and joint research studies on the levels of radiation and the health effects due to the radiation in the region. The scope of these studies includes the simultaneous and time integrated measurements of both inhalation dose and external gamma dose due to environmental radiation, which are useful in the analysis of epidemiological studies.

The aim of this study is to investigate the concentration factor of primordial radionuclides in locally grown foodstuffs in the south west coast of Kerala. The data will be useful for the estimate on of the internal radiation dose originating from them. We have analyzed food crops grown in the High Background Radiation Area (HBRA) for their radioactive concentration of radionuclides ^{40}K, ^{226}Ra and ^{228}Th. The dietary habit study noticed that locally grown food crops are the major part of the diet of the population in the region. We have analyzed Plantain, Banana, Spinach, Cauliflower, Cabbage, Ash Gourd, Ivy gourd, Bitter Gourd, Nanakizhangu, Tapioca, Yam, Colocassia and Elephant Foot collected from the growers.

METHODOLOGY

Study area

For the present study, 75 samples were collected from the coastal villages in Karunagappally taluks in Kollam district of Kerala State. The study area is bounded by the lat-long coordinates, 8-10^0 East and 76^0 25'-76^0 50' North covering about 65 square kilometer.

Sample collection & preparation

The locally grown vegetables and fruits were collected from local farmers and household growers. Only the edible portions of the plants were collected for the analysis [1]. 75 samples of 12 varieties of locally grown food crops were collected as per the Environmental Measurements Laboratory Procedure Manual [2] for analysis. The samples were washed under tap water to remove all the attached dust and sand particles. From the samples collected the edible parts were taken separately and its net wet weight was noted. Then samples were chopped and spread on a clean table and were allowed to dry in room temperature under an Infrared lamp for about 24 hours. Samples were oven dried at 110^o C, homogenized, accurately weighed. These coarse samples were further fired at about 300-320^o C to get make pure ash of sample. The ashes of the samples were then transferred to clean sample containers of specific size and were hermetically sealed and then packed in appropriate measuring geometries and sealed, in order to prevent 222Rn leakage. Measurements were carried out on the samples after an ageing time of about 40 days, in order to allow the re-establishment of radioactive equilibrium between 222Rn and its short lived daughter products.

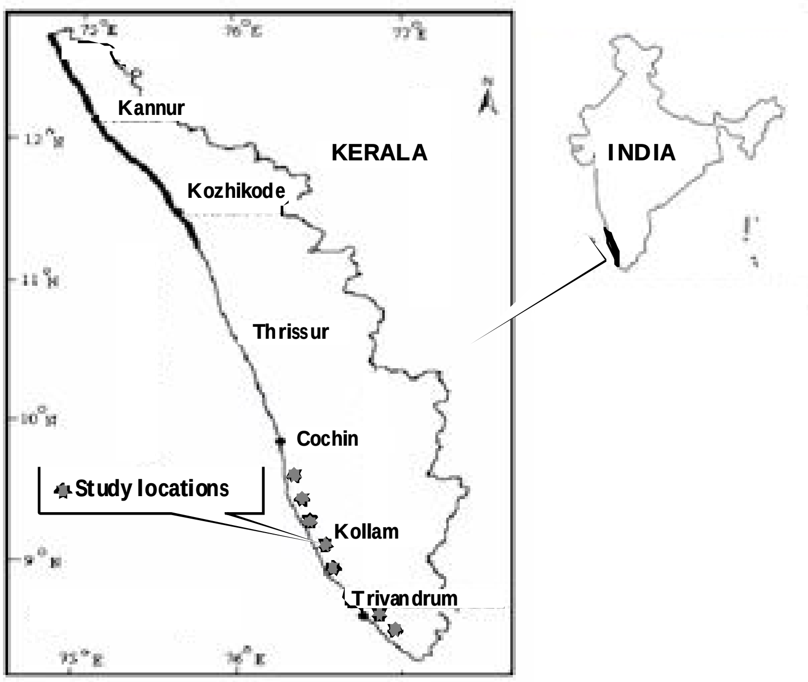

Figure1. Approximatelocations of sample collection in the study area.

75 Soil sample also collected from the same location of the food sample for analysis as per the Environmental Measurements Laboratory Procedure Manual [3]. The soil samples were taken after removing 10cm surface soil and were brought to the lab in clean polyethylene covers. The soil samples were then dried in an oven for 24 h at 110^0C and were crushed, sieved and hermetically sealed. The samples were then stored for a period 40 days to attain a secular radioactive equilibrium with the progeny nuclides.

Soil-plant-man is the major pathway for the transfer of radionuclides to human beings [4]. Radionuclides in soil are usually transferred to different plant tissues by direct transfer via the root system, or by fallout of radionuclides and resuspension of contaminated soil followed by deposition on plant leaves [5, 6]. In most cases, their concentrations in the plants are high when the presence of radionuclides is high in soil. A linear relationship can be seen when there is a constant ratio of plant to soil concentration [7, 8].

Migration and accumulation of pollutants in the soil-plant organization is complex. The capacity of various plant species to absorb radionuclides from soil or other substrates is expressed in terms of the concentration ratio (CR) which is also referred to as transfer factor (TF) represented by [9].

$$\mathbf{CR} = \frac{\textbf{Concentration of radionculides invegetables } (\mathbf{Bqkg^{-1}})}{\textbf{Concentration of radionuclides in soil } (\mathbf{Bqkg^{-1}})}$$

ISSN:0971-1260
Vol-22- Issue-14-December-2019

The concentration ratio is widely used in environmental transport models and describes the amount of nuclide expected to enter a plant from its substrate [10]. There are several factors such as soil characteristics, climatic conditions, type of plants, part of the plant concerned, physio-chemical form of the radionuclides and the interfering elements which influence the CR / TF values [11]. There are considerable differences in the uptake and translocation of long-lived radionuclides among different plant species. So far, several investigations on mobilization of natural radionuclides (such as ^{238}U and ^{226}Ra) in different sections (soil, plant, and water), as well as the transfer between them, have been performed at different high back ground radiation area around the world [12, 13]. But there is no information about the transport of ^{238}U, ^{226}Ra and ^{232}Th from soil to plant in temperate to tropical climate eco-systems in southwest coast of Kerala. The objective of this work was to investigate the uptake and soil-to-plant transfer factors of radionuclides (^{238}U, ^{226}Ra and ^{232}Th) HBRA in southwest Coast of Kerala, where the thorium content of monazite is 8-10%. Therefore, the aim of the present investigation was to determine the accumulation of ^{40}K, ^{226}Ra and ^{232}Th by some local vegetables and other common crops consumed by the local population. It is also used for assessing the consequences of radiation exposure to non-human biota [14].

Experimental

The activity concentrations of 226Ra, 232Th and 40K radionuclides in vegetable and fruit samples were determined using a gamma spectroscopic system, comprising a 5" x 4" NaI(Tl) well-type detector and a detector surrounded by a 3" thick cylindrical lead shield is connected with a dedicated PC for data storage and analysis.

The counting period for samples and background was set for 60000 s. The activity of ^{40}K was evaluated from the 1460keV photo peak of its own gamma, the activity of ^{226}Ra from1764 KeV gamma of ^{214}Bi and that of ^{232}Th from 2614 KeV gamma of ^{208}Tl in its series. The Minimum Detectable Level (MDL) evaluated for uranium was 4.7 Bq kg^{-1}for thorium 14.3 Bq kg^{-1} and for potassium 27.2 Bq kg^{-1}. The shielding for the detector well reduces the background resulting from cosmic radiation and from natural radioactive traces in the building materials. The gamma spectrum was recorded using a PC based multichannel analyzer and processed using the WinTMCA-32 Scintispec software.

RESULT AND DISCUSSION

The table-1 indicates that the concentration factor is slightly higher in tubers and leafy vegetables. The uptake factor for potassium is found to be uniformly high in all the vegetables, as it is one of the major nutrients for plants. Whereas tubers have higher intake of ^{232}Th from the soil, vegetables such as spinach, ivy guard and ash guard exhibit a higher tendency to absorb ^{238}U. But, the activity concentration of ^{232}Th in vegetables is higher in all samples compared to that of ^{238}U. So in vegetables thorium contributes more to the effective dose than that of uranium. The activity concentration of Potassium-40 is high compared to even that of thorium, but the dose rate depends mainly on the ^{232}Th concentration in vegetables due to its large conversion factor and, potassium content is held constant by metabolic processes. But some variation can be observed in spinach, yam, and cowpea**.** The high transfer factor reported here for tubers reveals

ISSN:0971-1260
Vol-22- Issue-14-December-2019

the high intake of radionuclide through their root system with multiplied thin hair roots spread all over the surface soil and hence tubers grown in this area have high activity and transfer factor.TF-Ra of the leafy vegetable, spinach ($1.1x10^{-1}$) was high when compare with other commonly consumed vegetables.

Sample	CR (Ra)	CR (Th)	CR (K)	Th/U
Ash Gourd	0.05	0.065	0.85	1.2
Banana	0.03	0.074	0.88	2.4
Cabbage	0.021	0.075	1.35	3.5
Cauliflower	0.03	0.05	0.695	1.6
Colocassia	0.025	0.105	1.3	4
Elephant Foot	0.02	0.135	0.62	6.7
Ivy gourd	0.05	0.08	0.69	1.6
Nanakizhangu	0.025	0.12	0.67	4
Papaya	0.019	0.05	0.545	2.6
Plantain	0.02	0.055	0.55	2.75
Spinach	0.11	1.58	2.05	14
Tapicca	0.025	0.098	1.09	3.9
Yam	0.036	0.33	1.01	8.25

Table 1. The concentration factor is slightly higher in tubers and leafy vegetables

CONCLUSION

The activity concentration of ^{232}Th in vegetables is higher in all samples compared to that of ^{238}U.The concentration factor is slightly higher in tubers and leafy vegetables. The uptake factor of potassium is found to be uniformly high in all the vegetables. TF-Ra of the leafy vegetable, spinach ($1.1x10^{-1}$) was high when compare with other commonly consumed vegetables.

ACKNOWLEDGEMENTS

The authors thankfully acknowledge the financial assistance from the Board of Research in Nuclear Sciences, DAE, India in the form of a research grant.

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