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Activity concentration of radionuclides in plants in the environment of Western Ghats

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Background: A field study on the transfer of primordial radionuclides ^{238}U, ^{232}Th, ^{40}K and fallout radionuclides ^{210}Po in different plant species in tropical forest of western Ghats environment is presented. ***Material and Methods:*** The Top storey, Second storey, Shrubs and epiphytic plant species were chosen and concentration of these radionuclides in plant and soil were measured by employing gamma ray spectrometer and alpha counter. ***Results:*** The concentration ratio shows the variation in different species while a wild plant *Elaeocarpus oblongus* and epiphytic plants indicated preferential uptake of these radionuclides. ***Conclusion:*** The dust trapped in the root system of epiphytic plants could be used as bioindicator to monitor fallout radionuclides in the Western Ghats. The concentration of ^{232}Th and ^{40}K in leaves depends on the age of the leaves. **Iran. J. Radiat. Res., 2009; 7 (2): 85-90**

Keywords: *Western Ghats, Primordial radionuclides, Concentration ratio, Elaeocarpus oblongus, bioindicator.*

INTRODUCTION

Irrespective of biological necessity, plants have been observed to take up many cations present in their root region. Primordial radionuclides are no exception for the same due to presence of monazite sands in the study area. In the soil, each radioactive element follows complex dynamics in which a part of its concentration is transported into the soil solution, while another part gradually becomes strongly bound to the particles of the soil. The portion of these radionuclides, which is in the soil solution, can be incorporated via the root into the plants. In some cases (U and Th), this is facilitated by their chemical similarity with other elements that the plant normally uses for its growth. It is important to study their dynamic in soil and their transfer to plants as theses are basic links in evaluating the transport of these radionuclides along the food chain. To quantify the transfer of a radionuclide from soil to the plant, one generally uses the corresponding transfer coefficient, obtained as the ratio between the activates of the radionuclides under the consideration in the said compartment. Among the radionuclides fall out radionuclide ^{210}Po is closely associated with atmospheric moisture and dust particles. The epiphytic plants depend on atmospheric moisture and dust particles for their nutrients resulting in a potentially higher absorption and accumulation of atmospheric ^{210}Po. The prominent tree species of the region *Elaeocarpus oblongus and Michelia nilagirica (top storey), Vaocinium nilgherrense and Viburnum hebanthum (short storey), Lasianthus coffeoiaes and Hedyotis stylosa (shrubs), and Cymbidium aloifolium (an orchid)* were selected for analysis. Data on primordial radionuclide concentration in the plants of Western Ghats region have not previously been reported and the present study is first systematic effort to provide data on this aspects. Therefore primary aim of this work is provide data on natural radioactivity and soil to plant transfer factor for the predominant plants species of Western Ghats region. Although the species selected for the present study are not directly involved in the human food chain, information on the concentration of radionuclides and their transfer factor are important since they help in predicting the soil to plant transfer of radionuclide.

MATERIALS AND METHODS

Study Area

The Nilgiris are well-defined massif that forms the southern limit of the main

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Western Ghats system that stretches unbroken from Mumbai in the north to the Nilgiris in the South (figure 1). The altitude of this region varies from 1700 to 2400 m above Mean Sea level. This is one of the oldest and most important ecosystems in Indian peninsula. The annual average rainfall is 1590 mm. The annual temperature variation is from around 4°C to 24°C. The total duration of rainy season is about 5 months, from June to October. The soil in the study area is predominantly lateritic, dark brown, loamy textured with fine medium grains.

Sample collection

Elaeocarpus oblongus, Michelia nilagirica, Vaocinium nilgherrense, Viburnum hebanthum, Lasianthus coffeoiaes, and Hedyotis stylosa tree leaves samples of 2kg were collected from the different places within the forest of Long wood and the surface soil samples were also collected (5cm deep) at four different places under the host trees, mixed thoroughly and about 2kg of composite sample was collected in polythene bag. The *Cymbidium aloifolium* leaves were collected along with soil dust trapped in the root system. Apart from this the most commonly observed tree species of the region *Elaeocarpus oblongus* were selected and leaf samples of the above tree species were collected from the sampling station once in May and again in December. Soil sample also collected from same locations from where the vegetation samples were collected.

Sample processing

Vegetation samples were dried in an oven at 110°C and about 30g samples were taken for the wet ashing and subsequent analysis of ^{210}Po. The remaining samples were charred over a low flame and converted into uniform white ash using a muffle furnace at 400°C and similarly soil samples were dried in an oven at 110°C and taken for the analysis.

Activity Determination

The primordial radionuclides activities were estimated using a g ray spectrometer, which consisted of '3×3' NaI (Tl) detector. The soil samples were analysed by NaI (Tl) spectrometer, which was coupled with TNI PCA II Ortec model 8K multichannel

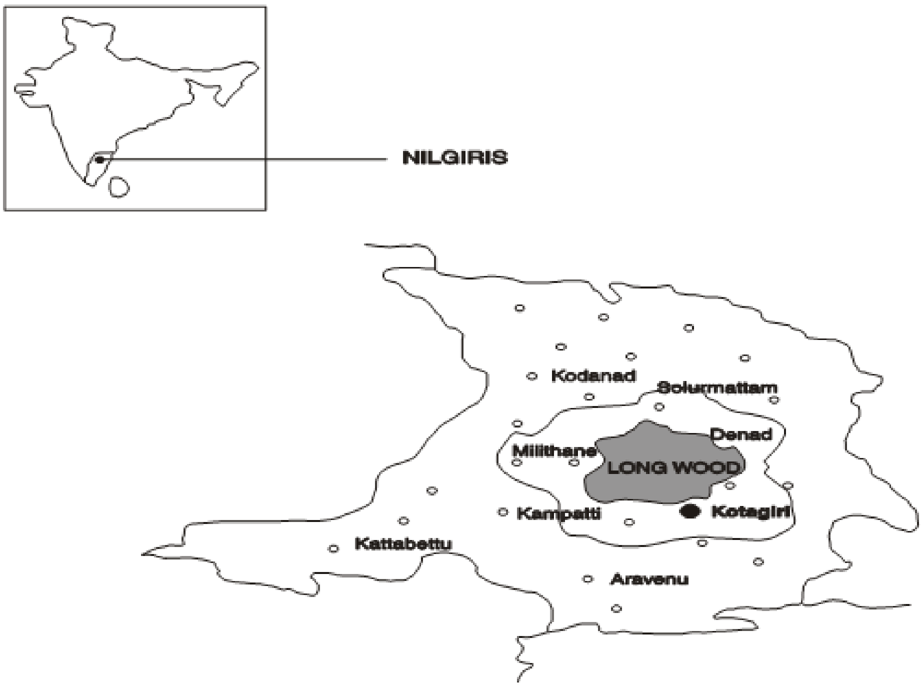

Figure 1. Study Area: Long wood Shola (Forest) in kotagiri Taluk.

analyzer. A 3”×3”NaI (Tl) detector was employed with adequate lead shielding which reduced the background by a factor of 95. The efficiency of various energy was arrived at using IAEA standard source and the required geometry. The system was calibrated both in terms of energy response and also for counting efficiency. The density of the sample used for the calibration was 1.3 gm/cm^3 which was same as average of soil sample analysed (1.24 gm/cm^3) with the counting time of 20, 000 sec for each sample and a very good shielding to the detector the minimum detectable concentration was 7 Bq/kg for ^{232}Th series, 8.4Bq/kgfor ^{238}U series and 13.2Bq/kg for ^{40}K at 3s confident levels. The concentrations of various radionuclides of interest were determined using the counting spectra of each sample. The peaks corresponding to 1.46Mev (^{40}K), 1.76MeV (^{214}Bi) and 2.614MeV (^{208}Tl) were considered for the evaluation of the activity levels of ^{40}K, ^{238}U series and ^{232}Th, respectively. The resolution of the crystal detector was 6% for ^{40}K, 4.4% for ^{232}Th series and 5.5% for the ^{238}U series. The activity analysis of gamma spectra obtained for each soil sample was performed with a dedicated software and the choice of reference was made so that they were sufficiently discriminated. Details of the detector and the calibration of the system were presented in the previous paper (1-3).

To determine the concentration of ^{210}P, about 30g of dried samples were taken. To start with, the samples were digested with 4N HNO_3 then with 8N HNO_3 and with a mixture of concentrated HNO_3 and H_2O. The digested samples were brought to the chloride medium by adding 0.5N HCl solution. Then ^{210}Po was deposited on a background count brightly polished silver disc through electro chemical exchange method (4, 5). Then it was counted in ZnS [Ag] alpha counter of background 0.2cpm and efficiency 30%. Polonium- 210 activity was estimated using the standard methods (6, 7).

RESULTS AND DISCUSSION

Results of mean activity concentration these radionuclides in different plants are presented in table 1. All the species, except *Cymbidium aloifolium (an orchid)* having a similar growing habit and shed their leaves at the end of every growing season i.e during the last days of winter. Leaves start budding during the last day of summer. It is clear from the table that the activity concentration of ^{238}U in the leaves is below detectable limit i.e. very low in most of the plants and the concentration of ^{232}Th is quite significant in the all plants, this reveals the nature of soil presented in the study area (1-3).

But the concentration of ^{40}K is greater in the leaves of the plant except the Cymbidium *aloifolium.* This can be attributed to the fact that *Cymbidium aloifolium* being epiphytic plants depend mainly on atmospheric dust and on atmospheric moisture for its nutrients where as other plants take their nutrients directly from the soil in which ^{40}K concentration is higher compared to the dust trapped in the root dust of *Cymbidium aloifolium.* Also, the concentration ^{210}Po is high compared to other radionuclides in all plant samples. This is due to the partial diffusion of ^{222}Rn from the earth surface into atmosphere decays continuously to ^{210}Po through various other short lived and long lived radionuclides. Therefore the concentration of ^{210}Po which returns to the biosphere and earth’s surface through dry and wet fallout will be continuous (8). These results suggested that the dust trapped in the root system of *Cymbidium aloifolium* could be used conveniently as an indicator of fallout radionuclides from the natural origin.

In general, the highest activity concentration in plants was found in those collected from areas with the highest radioactivity concentration in soil substrate but the activity concentration in the plants are not linearly related to the activity in soil. From the results activity concentration of radionuclides in soil and plants, values of CR [CR=Activity of radionuclide in plant (Bqkg^{-1} dry weight)/ Activity of radionuclides in soil (Bqkg^{-1} dry weight)] [9] has been calculated. The results are presented in the table 1 for the primordial and fallout radionuclides. CR values for ^{238}U, ^{232}Th, ^{210}Po and ^{40}K were found to have the range of BDL to 0.313, 0.257 to 0.341, 0.274 to 0.368 and 0.802 to 0.954. CR value for ^{210}Po and ^{40}K is considerably higher than other radionuclides, which suggests higher levels of uptake of these radionuclides. It is interesting to note that although all the tree species are grown in soils of similar physical -chemical characteristic and similar concentration of these radionuclides, the CR values are different for different species. This indicates that the some plant species concentrate higher ^{210}Po and ^{40}K radionuclides than the others, Karunakara *et al.* 2001[10] observed the same.

Root uptake of radionuclides is a complex phenomenon, especially for primordial nuclides. According to CR Principles, plant radionuclide concentration should reflect soil concentration. However, this may not be true because of sorption on soil, which may render radionuclides less available for uptake [16]. Furthermore, radionuclide belonging to physiologically regulated elements, or their analogues, may be selectively adsorbed, where as others may be excluded. The low activity concentration of radionuclides in plants can be observed clearly in most of the plant species except *Eleaocarpus oblangus* and in the epiphytic plant and also its difficult to arrive a conclusion that uptake of these radionuclides. Significant difference in radioactivity concentration of these radionuclides between plant species is likely caused by physiological difference and related factors.

The CR for orchid is low due to the fact that the orchids do not take their nutrients from soil but absorbs them directly from atmosphere (Parfenov-1974) [11] and that is the reason why the CR value of fallout radionuclide Po is much higher in the plant

Table 1. Activity concentration of Radionuclides in plants and its CR values.

Plant species	Activity concentration in soil in Bq/kg				Activity concentration in Plants in Bq/kg				CR			
	^{232}Th	^{238}U	^{210}Po	^{40}K	^{232}Th	^{238}U	^{210}Po	^{40}K	^{232}Th	^{238}U	^{210}Po	^{40}K
Elaeocarpus oblongus	59.9	36.1	45.6	216.3	18.4	11.3	16.8	206.4	0.341	0.313	0.368	0.954
Michelia nilagirica	51.6	33.6	41.3	203.4	14.1	BDL	11.3	163.2	0.273	BDL	0.274	0.802
Vaocinium nilgherrense	64.6	38.5	44.1	213.8	16.9	9.6	13.5	187.4	0.262	0.249	0.306	0.877
Viburnum hebanthum	50.9	30.7	34.7	186.8	14.3	BDL	10.9	160.4	0.281	BDL	0.314	0.859
Lasianthus coffeoiaes	64.8	39.8	47.5	222.9	17.5	10.1	13.8	186.8	0.270	0.254	0.291	0.838
Hedyotis stylosa	75.4	43.4	49.5	246.7	19.4	11.2	14.6	203.4	0.257	0.258	0.295	0.824
Cymbidium aloifolium					14.3	BDL	20.19	26.98	0.224	BDL	0.43 1	0.128
Root dust	16.7	14.3	56.31	19.84								
Surface soil	63.8	38.4	46.8	210.2								

of orchid. The value of CR reported by Zach et al (1989) [12] for ^{40}K varied in the range of 0.12-0.60, which is comparable with the present study. Figure 1 shows the correlation between CR values of different plants for different radionuclides ^{210}Po vs. ^{40}K, and ^{210}Po vs. ^{40}K. A good correlation (figure 2a, r = 0.946) (figure 2b, r = 0.701) is observed between the CR values of these two radionuclides.

Also the higher concentration of fallout radionuclides in root dust must be due to the accumulation of atmospheric fallout over a long period of time through dry wet deposition and due to strong adsorption of these nuclides to soil particles. The deposition fallout radionuclides on the upper layer of the earth crust may get washed out due to heavy rain. This leads to the movement of fallout nuclides along with surface soil, where as root dust keeps on accumulating without any movement [13].

CR values for different kind of plants species like Top storey, Second storey, Shrubs and epiphytic were shows different. Thus it is clear that the different in physical characteristics in different plant species have a large effect on the accumulation of radionuclides in plant [13]. As discussed earlier, plants may take up potassium from soil as an essential element of metabolism and other radionuclides may be taken as a homologue of an essential element [14].

It is interesting that the uptake of these radionuclides is relatively higher in the plant of *Eleaocarpus oblangus*. To evaluate the dependence of CR values on the age of the leaves, samples of *Eleaocarpus oblangus* were collected in different growing periods of the leaves, once when the leaves have just started budding and again when the leaves are about to shed, and analyzed for the ^{232}Th, ^{210}Po and ^{40}k concentrations. The results are presented in table 2. It is interesting to note that the mean value of their CR values collected in May is higher than those in December except for ^{210}Po. The increase in the activity is significant in the case of ^{40}k. These results suggested that CR values of ^{232}Th and ^{40}K for leaves depend on the age of the leaves.

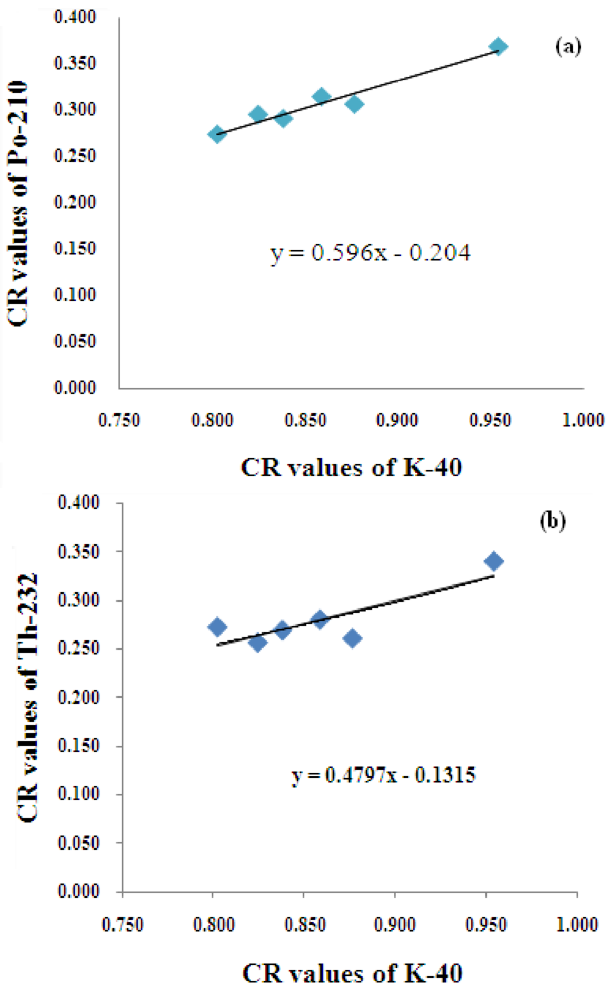

Figure 2. Correlation between CR values of different Radionuclides (a - ^{210}Po, b - ^{232}Th) vs. ^{40}K.

Table 2. CR values of ^{232}Th, ^{210}Po and ^{40}K in different growing period of the leaves.

Name of the Plant species	Mean value of CR					
	May			December		
Eleaocarpus oblangus	^{232}Th	^{210}Po	^{40}K	^{232}Th	^{210}Po	^{40}K
	0.341	0.368	0.945	0.302	0.351	0.531

CONCLUSION

The study has provided data on Primordial and fallout radionuclides activities in some of the predominant plant species of the Western Ghats region. The Plants shows significant concentration of Th. The concentration of ^{40}K is higher in the leaves of the *Elaeocarpus oblongus,* whereas the concentration of natural fallout radionuclides ^{210}Po is higher in epiphytic root dust of *Cymbidium aloifolium (an orchid).* The dust trapped in the root system of *Cymbidium aloifolium* could be used as bioindicator to monitor natural fallout radionuclides in the Western Ghats Environment. The CR value of ^{232}Th and ^{40}k depends on the age of the leaves.

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REFERENCES

1. Manigandan PK (2007) Distribution of radionuclides in the forest soils (Western Ghats -India). *IJRR,* **5***: 17-22.*
2. Manigandan PK (2008) Bio-indicators in the tropical forest of Western Ghats Environment. *IJRR,* **5***: 115-122.*
3. Manigandan P K (2008) Migration of radionuclide in soil and plants of Western Ghats Environment. *IJRR,* **6***: 165-170.*
4. Martinez-Aquire A, Garcia-orellana I, Garcia-leon M (1997). Transfer of natural radionuclides from soils to plant in a marsh enhanced by the operation of non-nuclear industries. *J Environ R,* **35***: 149 –171.*
5. Timpereley MH, Brooks RR, Peterson PI (1970) The significant of essential and non-essential trace elements in plants in relation to biogeochemical prospecting. Journal Appl. Ecol., **7**: 429-39.
6. Iyengar MAR., Ganapathy S, Kannan V, Rajan MP, Rajaram S (1990) Procedure manual, workshop on environmental radioactivity, Kiga, India.
7. Anand SJS and Rangarajan C (1990) Studies on the activity ratio of ^{210}Po to ^{210}Pb and their dry deposition velocities at Bombay in India. *J Environ Radioactivity,* **11***: 235-50.*
8. Karunakara?? *et al.* (2000). Distribution and enrichment of ^{210}Po in the environment of Kaiga in south India. *J Environmental activity,* **51***: 349-363.*
9. Frissel MJ (1997) Protocol for the experimental determination of radionuclide transfer factors to be used in radiological assessment models. *UIR News letter,* **28***: 5-8.*
10. Karunakara *et al.* (2001) ^{226}R, ^{232}Th and ^{40}K concentration in soil samples of Kaiga of south west coast of India. *Health Physics,* **80***: 470-476.*
11. Parfenov YD (1974) ^{210}Po in the environment and in the human organism. *Atomic energy review,* **12***:75-143.*
12. Zach R, Hawkin JL, Mayoh KR (1989) Transfer of fallout cesium and natural Potassium-40 in boreal environment. *J Environmental activity,* **10***: 19-45.*
13. Cawse PA and Turner GS (1982) The uptake of radionuclides by plants (Harwell: Environmental and medical sciences division AERE)
14. Sheppared SC and Evenden?? (1988) The assumption of linearity in soil and plant concentration ratio: An experimental evaluation. *Journal environmental Radioactivity,* **7***: 221-47.*