International Scholars Journals

International Journal of Agroforestry and Silviculture ISSN 2375-1096 Vol. 8 (5), pp. 001-005, May, 2020. Available online at www.internationalscholarsjournals.org © International Scholars Journals



*Full Length Research Paper*

# Activity concentration of radionuclides in plants in the environment of western Ghats, India

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Accepted 16 July, 2019

**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, India, is presented. Material and Methods: The Top storey, Short storey, Shrubs and Epiphytic plant species were sampled and concentration of these radionuclides in plant and soil were measured by employing a gamma ray spectrometer and an alpha counter. Results: The soil-plant concentration ratio shows the variation of radionuclide accumulation in different species while a wild plant *Elaeocarpus oblongus* and epiphytic plants indicated preferential uptake of these radionuclides. Conclusion: The dust particles 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**

**Key words:** 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, and these are present due to existence of monazite sands in the study area. In the soil, each radioactive element follows complex dynamics in which part of it is transported into the soil solution, while another part gradually becomes strongly bound to the soil particles of the soil. The portion of these radionuclides 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 these are basic links in evaluating the transport of 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 activity concentrations of the radionuclides under consideration in the said compartments. Among the radionuclides of interest, fallout 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 in such Ephyphitic species.

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 been reported previously and the present study is the first systematic effort to provide data on this respect. Therefore, primary aim of this work is provide data on natural radioactivity concentrations and soil to plant transfer factors 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 radio-nuclides 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 Western Ghats system that stretches unbroken from Mumbai in the north to the Nilgiris in the South of India (Figure 1). The altitude of this region varies from 1700 - 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


**Figure 1.** Study area: Long wood shola (forest) in Kotagiri Taluk.

annual temperature variation is from around 4 - 24°C. The total duration of rainy season is about 5 months, from June - October. The soil in the study area is predominantly lateritic, dark brown, loamy textured with fine medium grains

**Sample collection**

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

**Sample processing**

Vegetation samples were dried in an oven at 110°C and about 30 g 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 radionuclide activities were measured using a $\gamma$ ray spectrometer, which consisted of a ‘3x3’ NaI (Tl) detector coupled with a TNI PCA II Ortec model 8K multichannel analyzer. The 3”x3”NaI (Tl) detector was protected from ambient radiation with adequate lead shielding which reduced the background by a factor of 95. The efficiency for various gamma energies was determined through using an IAEA standard source and the required geometry. The system was calibrated both in terms of energy response and counting efficiency. The density of the sample used for the calibration was 1.3 gm/cm$^3$ which were nearly the same as the average of soil samples analyzed (1.24 gm/cm$^3$). The soil samples were analysed with the NaI (Tl) spectrometer, for a 20, 000 sec counting time for each sample. The minimum detectable concentration (MDC) was 7 Bq/kg for $^{232}$Th series, 8.4Bq/kg for $^{238}$U series and 13.2Bq/kg for $^{40}$K at 3$\sigma$ confidence level. The concentrations of several radionuclides of interest were determined in each sample. The peaks corresponding to 1.46Mev ($^{40}$K), 1.76MeV ($^{214}$Bi) and 2.614MeV ($^{208}$Tl) were used in the evaluation of the activity levels of $^{40}$K, $^{238}$U series and $^{232}$Th, respectively. The re-solution 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 concentration of radi-onuclides measured in soil samples was calculated through the use of dedicated software and the choice of reference was made so that they were sufficiently discriminated. Details of the detector and calibration of the system were presented in the previous papers (Manigandan, 2007, 2008).

To determine the concentration of $^{210}$Po, about 30 g of dried samples were taken. To start with, the samples were digested with 4 N $HNO_3$ 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 0.5 N HCl solution. Then $^{210}$Po was deposited on a background count brightly polished silver disc through electro chemical exchange method (Martinez-Aquire et al., 1997; Tim-pereley et al., 1970). 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 (Iyengar et al., 1990; Anand and Rangarajan, 1990).

## RESULT AND DISCUSSION

Results of mean activity concentration of these radio-nuclides in different plants are presented in Table 1. All the species, except *C. aloifolium* (an orchid), have a similar growing pattern and shed their leaves at the end of every growing season, that is, during the last days of winter. Leaves start budding during the last day of summer. It is clear from the Table 1 that the activity concentration of $^{238}$U in the leaves was below the detection limit, that is, very low in most of the plants, and the concentration of $^{232}$Th is quite significant in the other plants, revealing the nature of soil existing in the study area (Manigandan, 2007, 2008).

The concentration of $^{40}$K is greater in the leaves of the plants, with exception of *C. aloifolium*. This can be attributed to the fact that *C. aloifolium* is an epiphytic plant depending upon mainly on atmospheric dust and on atmospheric moisture as source of nutrients and water while other plants take their nutrients and water through root uptake from the soil in which $^{40}$K concentration is higher compared to the dust trapped in the root dust of *C. 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 earth surface into the atmosphere, where it decays 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 (Karunakara et al., 2000). These results suggested that the dust trapped in the root system of the epiphyte *C. aloifolium* could be used conveniently as an indicator of fallout radionuclides from the natural origin. In general, the highest activity concentrations in plants were measured in those collected from areas with the highest radioactivity concentrations in soils. However, the activity concentration in the plants was not linearly cor-related to the activity in soil. From the results on activity concentration of radionuclides in soils and plants, the CR values [CR = Activity of radionuclide in plant (Bqkg$^{-1}$ dry weight)/ Activity of radionuclide in soil (Bqkg$^{-1}$ dry weight)) (Frissel, 1997) have 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 range from the MDC to 0.313, 0.257 to 0.341, 0.274 to 0.368, and 0.802 to 0.954, respectively. The CR values for $^{210}$Po and $^{40}$ K were considerably higher than for other radionuclides, which suggest 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 characteristics and similar concentration of radionuclides, the CR values are dif-ferent for different plant species. This indicates that the some plant species concentrate higher $^{210}$ Po and $^{40}$K radionuclides than the others. Karunakara et al 2001 (Karunakara et al., 2001) observed the same.

Root uptake of radionuclides is a complex pheno-menon, especially for primordial nuclides. According to the CR concept, plant radionuclide concentration should reflect soil concentration. However, this may not be true because of sorption on soil, which may render radi-onuclides less available for uptake in some soils. Fur-thermore, radionuclides of physiologically regulated che-mical elements, or their analogues, may be selectively adsorbed, while others may be excluded. The low activity concentration of radionuclides in plants can be observed clearly in most of the plant species analyzed, except in *E. oblangus* and in the epiphytic plants. Significant dif-ferences in radioactivity concentration of these radio-nuclides observed amongst plant species is likely caused by plant physiological differences 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) and that is the reason why the CR value of fallout radionuclide Po is much higher in the plant of orchid. The value of CR reported by Zach et al (1989) for $^{40}$K varied in the range of 0.12 - 0.60, which is comparable to the value reported in the present study. Figure 1 shows the correlation between CR values of different plants for different radionuclides $^{210}$Po vs $^{40}$K, and $^{232}$Th 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 radio-nuclides.

Also the higher concentration of fallout radionuclides in plant roots soil particles 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 those nuclides to soil particles. The deposition fallout radi-onuclides on the upper layer of the earth crust may get washed out by heavy rains. This leads to the movement

**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 |
| *E. 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 |
| *M. nilagirica* | 51.6 | 33.6 | 41.3 | 203.4 | 14.1 | BDL | 11.3 | 163.2 | 0.273 | BDL | 0.274 | 0.802 |
| *V. 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 |
| *V. hebanthum* | 50.9 | 30.7 | 34.7 | 186.8 | 14.3 | BDL | 10.9 | 160.4 | 0.281 | BDL | 0.314 | 0.859 |
| *L. 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 |
| *C. aloifolium* | | | | | 14.3 | BDL | 20.19 | 26.98 | 0.224 | BDL | 0.431 | 0.128 |
| Root dust | 16.7 | 14.3 | 56.31 | 19.84 | | | | | | | | |
| Surface soil | 63.8 | 38.4 | 46.8 | 210.2 | | | | | | | | |

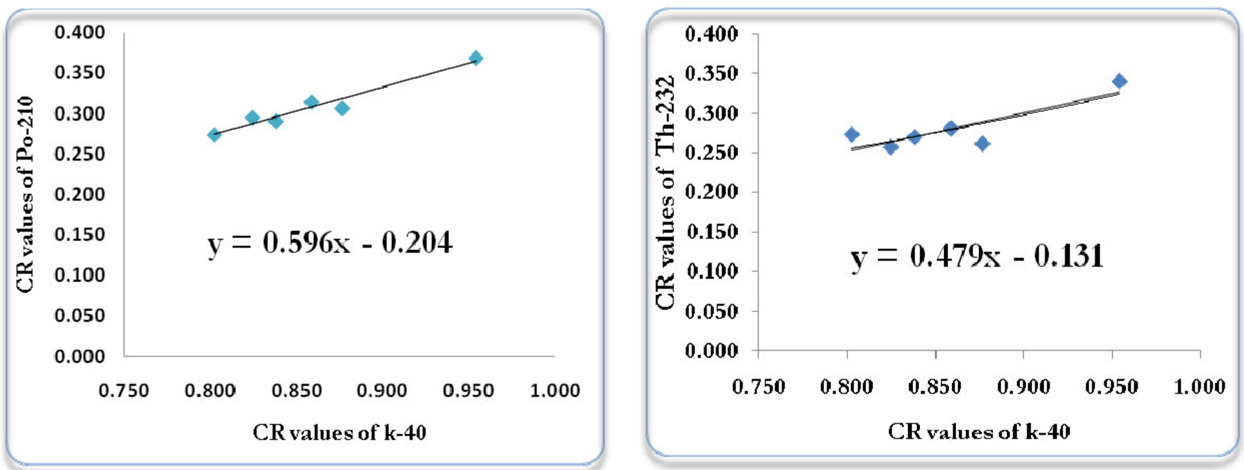


**Figure 2.** Correlation between CR values of different Radionuclides (a - $^{210}$Po, b - $^{232}$Th) vs $^{40}$K.

movement of fallout nuclides along with surface soil, where as root dust keeps on accumulating without any movement (Cawse and Turner, 1982).

CR values for different kind of plants species like Top storey, Second storey, Shrubs and Epiphytic plant shows differences. 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 (Sheppard and Evenden,1988).

It is interesting that the uptake of these radionuclides is relatively higher in the plant of *E. oblangus*. To evaluate the dependence of CR values on the age of the leaves, samples of *E. 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.

## Conclusions

The study has provided data on primordial and fallout radionuclides activities in some of the predominant plant species at the Western Ghats region. The plants showed significant concentrations of Th. The concentration of $^{40}$K was higher in the leaves of *E. oblongus,* whereas the concentration of natural fallout radionuclides $^{210}$ Po was higher in epiphytic root dust of *C. aloifolium* (an orchid). The dust trapped in the root system of *C. aloifolium* could be used as bioindicator to monitor natural fallout radionu-

**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 | | | | | |
|---|---|---|---|---|---|---|
| *E. oblangus* | May | | | December | | |
| | $^{232}Th$ | $^{210}Po$ | $^{40}K$ | $^{232}Th$ | $^{210}Po$ | $^{40}K$ |
| | 0.341 | 0.368 | 0.945 | 0.302 | 0.351 | 0.531 |

clides in the Western Ghats Environment. The CR value of $^{232}Th$ and $^{40}k$ depends on the age of the leaves.


## ACKNOWLEDGEMENT

The author is thankful to Dr. A. Natarajan, Head, HASL, IGCAR, Dr. A. R. Lakshmanan. HASL, IGCAR, Dr. A. R. Iyengar, Head, ESL, Kalpakkam for their constant encourage throughout the period of work.


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