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 coffeeaes 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...
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 γ 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
Activity concentration of radionuclides in plants

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 all the 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

To determine the concentration of $^{210}$Po, 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$_2$O. 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 ($^{4}$, $^{9}$). 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 ($^{6}$, $^{7}$).
are not linearly related to the activity in soil. From the results activity concentration of radionuclides in soil and plants, values of CR \( CR = \text{Activity of radionuclide in plant (Bqkg}^{-1}\text{ dry weight)}/ \text{Activity of radionuclides in soil (Bqkg}^{-1}\text{ dry weight)} \) \(^{(9)}\) has been calculated. The results are presented in the table 1 for the primordial and fallout radionuclides. CR values for \(^{238}\text{U}, ^{232}\text{Th}, ^{210}\text{Po} \) and \(^{40}\text{K}\) 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 \(^{210}\text{Po} \) and \(^{40}\text{K}\) 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 \(^{210}\text{Po} \) and \(^{40}\text{K}\) 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 \(^{(10)}\). 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 \textit{Elaeocarpus oblangus} and in the epiphytic plant and also its difficult to arrange 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>
<thead>
<tr>
<th>Plant species</th>
<th>Activity concentration in soil in Bq/kg</th>
<th>Activity concentration in Plants in Bq/kg</th>
<th>CR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( ^{232}\text{Th} ) ( ^{238}\text{U} ) ( ^{210}\text{Po} ) ( ^{40}\text{K} )</td>
<td>( ^{232}\text{Th} ) ( ^{238}\text{U} ) ( ^{210}\text{Po} ) ( ^{40}\text{K} )</td>
<td>( ^{232}\text{Th} ) ( ^{238}\text{U} ) ( ^{210}\text{Po} ) ( ^{40}\text{K} )</td>
</tr>
<tr>
<td>\textit{Elaeocarpus oblangus}</td>
<td>59.9 ( ^{232}\text{Th} ) 36.1 ( ^{238}\text{U} ) 45.6 ( ^{210}\text{Po} ) 216.3 ( ^{40}\text{K} )</td>
<td>18.4 ( ^{232}\text{Th} ) 11.3 ( ^{238}\text{U} ) 16.8 ( ^{210}\text{Po} ) 206.4 ( ^{40}\text{K} )</td>
<td>0.341 ( ^{232}\text{Th} ) 0.313 ( ^{238}\text{U} ) 0.368 ( ^{210}\text{Po} ) 0.954 ( ^{40}\text{K} )</td>
</tr>
<tr>
<td>\textit{Michelia nilagirica}</td>
<td>51.6 ( ^{232}\text{Th} ) 33.6 ( ^{238}\text{U} ) 41.3 ( ^{210}\text{Po} ) 203.4 ( ^{40}\text{K} )</td>
<td>14.1 ( ^{232}\text{Th} ) BDL ( ^{238}\text{U} ) 11.3 ( ^{210}\text{Po} ) 163.2 ( ^{40}\text{K} )</td>
<td>0.273 ( ^{232}\text{Th} ) BDL ( ^{238}\text{U} ) 0.274 ( ^{210}\text{Po} ) 0.802 ( ^{40}\text{K} )</td>
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<tr>
<td>\textit{Vaccinium nilgherrense}</td>
<td>64.6 ( ^{232}\text{Th} ) 38.5 ( ^{238}\text{U} ) 44.1 ( ^{210}\text{Po} ) 213.8 ( ^{40}\text{K} )</td>
<td>16.9 ( ^{232}\text{Th} ) 9.6 ( ^{238}\text{U} ) 13.5 ( ^{210}\text{Po} ) 187.4 ( ^{40}\text{K} )</td>
<td>0.262 ( ^{232}\text{Th} ) 0.249 ( ^{238}\text{U} ) 0.306 ( ^{210}\text{Po} ) 0.877 ( ^{40}\text{K} )</td>
</tr>
<tr>
<td>\textit{Viburnum hebanthum}</td>
<td>50.9 ( ^{232}\text{Th} ) 30.7 ( ^{238}\text{U} ) 34.7 ( ^{210}\text{Po} ) 186.8 ( ^{40}\text{K} )</td>
<td>14.3 ( ^{232}\text{Th} ) BDL ( ^{238}\text{U} ) 10.9 ( ^{210}\text{Po} ) 160.4 ( ^{40}\text{K} )</td>
<td>0.281 ( ^{232}\text{Th} ) BDL 0.314 ( ^{238}\text{U} ) 0.859 ( ^{210}\text{Po} )</td>
</tr>
<tr>
<td>\textit{Lasianthus coffeinaes}</td>
<td>64.8 ( ^{232}\text{Th} ) 39.8 ( ^{238}\text{U} ) 47.5 ( ^{210}\text{Po} ) 229.2 ( ^{40}\text{K} )</td>
<td>17.5 ( ^{232}\text{Th} ) 10.1 ( ^{238}\text{U} ) 13.8 ( ^{210}\text{Po} ) 186.8 ( ^{40}\text{K} )</td>
<td>0.270 ( ^{232}\text{Th} ) 0.254 ( ^{238}\text{U} ) 0.291 ( ^{210}\text{Po} ) 0.838 ( ^{40}\text{K} )</td>
</tr>
<tr>
<td>\textit{Hedyotis stylosa}</td>
<td>75.4 ( ^{232}\text{Th} ) 43.4 ( ^{238}\text{U} ) 49.5 ( ^{210}\text{Po} ) 246.7 ( ^{40}\text{K} )</td>
<td>19.4 ( ^{232}\text{Th} ) 11.2 ( ^{238}\text{U} ) 14.6 ( ^{210}\text{Po} ) 203.4 ( ^{40}\text{K} )</td>
<td>0.257 ( ^{232}\text{Th} ) 0.258 ( ^{238}\text{U} ) 0.295 ( ^{210}\text{Po} ) 0.824 ( ^{40}\text{K} )</td>
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<tr>
<td>\textit{Cymbidium aloifolium}</td>
<td>14.3 ( ^{232}\text{Th} ) BDL 20.19 ( ^{238}\text{U} ) 26.98 ( ^{210}\text{Po} )</td>
<td>0.224 ( ^{232}\text{Th} ) BDL 0.43 ( ^{238}\text{U} ) 0.128 ( ^{210}\text{Po} )</td>
<td></td>
</tr>
<tr>
<td>Root dust</td>
<td>16.7 ( ^{232}\text{Th} ) 14.3 ( ^{238}\text{U} ) 56.31 ( ^{210}\text{Po} )</td>
<td>19.84 ( ^{232}\text{Th} ) BDL 20.19 ( ^{238}\text{U} ) 26.98 ( ^{210}\text{Po} )</td>
<td>0.224 ( ^{232}\text{Th} ) BDL 0.43 ( ^{238}\text{U} ) 0.128 ( ^{210}\text{Po} )</td>
</tr>
<tr>
<td>Surface soil</td>
<td>63.8 ( ^{232}\text{Th} ) 38.4 ( ^{238}\text{U} ) 46.8 ( ^{210}\text{Po} )</td>
<td>210.2 ( ^{232}\text{Th} ) BDL 20.19 ( ^{238}\text{U} ) 26.98 ( ^{210}\text{Po} )</td>
<td>0.224 ( ^{232}\text{Th} ) BDL 0.43 ( ^{238}\text{U} ) 0.128 ( ^{210}\text{Po} )</td>
</tr>
</tbody>
</table>
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 *Eleocharpus oblangus*. To evaluate the dependence of CR values on the age of the leaves, samples of *Eleocharpus 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.

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

<table>
<thead>
<tr>
<th>Name of the Plant species</th>
<th>Mean value of CR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>May</td>
</tr>
<tr>
<td><em>Eleocharpus oblangus</em></td>
<td></td>
</tr>
<tr>
<td>$^{232}$Th</td>
<td>0.341</td>
</tr>
<tr>
<td>$^{210}$Po</td>
<td>0.368</td>
</tr>
<tr>
<td>$^{40}$K</td>
<td>0.945</td>
</tr>
</tbody>
</table>

![Figure 2. Correlation between CR values of different Radionuclides (a. $^{210}$Po, b. $^{232}$Th) vs. $^{40}$K.](https://www.SID.ir)
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 40K is higher in the leaves of the Elaeocarpus oblongus, whereas the concentration of natural fallout radionuclides 210Po 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 232Th and 40K depends on the age of the leaves.

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