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Full Length Research Paper

Transfer of natural radionuclides from soil to plants in tropical forest (Western Ghats – India)

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Soil and 2 wild plant species (*Evodia roxburghiana* and *Eleaocarpus oblangus*) have been collected from the western Ghats region and analysed for ^{210}Po and ^{238}U. The radioactivity concentrations in plants and soil reflect the impact of the existence of igneous nature of rock in the area of study. Concentration ratios (CR) of these radionuclides, between plants and underlying soil, have been studied and the results shows that the concentration ratios (CR) seem to be depend on radionuclides in soil.

Key words: Primordial radionuclides, Western Ghats, monazite, igneous rock, CR-concentration ratio.

INTRODUCTION

Environmental assessment use food chain models to be determine the dose to man from radionuclides released to the biosphere. A traditional food chain model requires a plant/substrate transfer coefficient, referred as concentration ratio (CR). The concentration ratio concept is generally accepted and widely used in environmental transport models and describes the amount of nuclide expected to enter a plants from its substrate. Many of reviews have been published in which Sheppard and Sheppard (1985) was observed a linear relation between the plant concentration and substrate concentration. Cannon (1952) has stated that U may be a micronutrient for higher plants, which means that CR was not linearly related to the substrate concentration. Mordberg et al. (1976) obtained CR value by fitting linear and hyperbolic functions to data obtained using different soil concentrations over their observed concentration. A hyperbolic relation for the CR for essential and non essential elements over a range of substrate concentrations was observed by Timperley et al. (1970), Mengel and Kirkby (1979) and concluded that plants readily take up elements essential for plant growth when concentrations are low, where as plant uptake of non-essential element is generally constant in this substrate concentration rage. We have previously, shown that activity concentration of thorium was high in the region of Western Ghats especially around the Nilgiris hill station due to the presence of monazite sand (Manigandan, 2007; Manigandan, 2008; Selvasekarapandian, 2000; Iyengar et al., 1990). Limited data is available to evaluate the environmental radioactivity in these parts of the region; therefore it was felt worthwhile to study the radioactivity in some tropical forest plants so that indicators can be identified for monitoring radioactivity. Prominent plants species of the region *Evodia roxburghiana* and *Eleaocarpus oblangus* were selected for analysis. The objective of the present study is to measure the concentration of radionuclides in soil and how they have been incorporated in the plants from its substrate concentration. Although these species are not directly involved in the human food chain, information on the concentration level and the transfer of radionuclides from contaminated soil will provide important data's on the transfer mechanism in the case of those species more directly involved in the human diet. Environmental assessment uses food chain models to determine the dosage for humans from radionuclides released to the biosphere.

MATERIALS AND METHODS

E. roxburghiana and *E. oblangus* plants 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 4 different places under the host trees, mixed thoroughly and about 2 kg of composite sample was collected in polythene bag. 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

Table 1. Activity concentration of radionuclides in soil and in the *E. oblangus* samples.

Sample number	Activity concentration in Soil [Bq/kg]		Activity concentration in Plant [Bq/kg]		CR	
	U - 238	Po - 210	U-238	Po-210	U - 238	Po - 210
1	36.09	45.13	9.47	10.60	0.262	0.210
2	36.77	40.22	9.70	10.92	0.264	0.241
3	47.41	55.63	11.62	13.80	0.245	0.209
4	36.10	44.40	9.93	12.18	0.275	0.224
5	33.56	40.53	9.83	11.54	0.293	0.243
6	31.66	36.15	8.64	10.79	0.273	0.239
7	27.42	37.79	8.79	10.46	0.321	0.233
8	37.57	47.39	9.64	11.27	0.256	0.203
9	42.26	51.61	10.30	12.61	0.244	0.199
10	39.31	49.92	9.90	11.99	0.252	0.198

Table 2. Activity concentration of radionuclides in soil and in the *E. roxburghiana* samples.

Sample number	Activity concentration in Soil [Bq/Kg]		Activity concentration in plant [Bq/Kg]		CR	
	U - 238	Po - 210	U - 238	Po - 210	U - 238	Po - 210
1	34.47	36.11	8.60	9.19	0.250	0.254
2	28.00	32.21	8.92	9.40	0.319	0.292
3	44.58	51.15	11.59	12.64	0.260	0.247
4	32.18	35.11	9.25	10.38	0.287	0.296
5	35.05	37.77	9.11	9.98	0.260	0.264
6	28.93	32.40	9.01	9.49	0.311	0.293
7	23.72	31.04	8.51	9.34	0.359	0.301
8	37.72	42.58	9.99	11.24	0.265	0.264
9	36.18	41.88	10.63	11.04	0.294	0.264
10	33.87	36.45	10.21	10.93	0.301	0.300

and similarly soil samples were dried in an oven at 110°C and taken for the analysis.

The primordial radionuclides activities were estimated using NaI (Tl) spectrometer, which was coupled with TNI PCA II Ortec model 8K multichannel analyzer. A 3" x 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 s for each sample and a very good shielding to the detector the minimum detectable concentration was 8.4 Bq/kgfor ^{238}U series at 3σ confident levels. Details of the detector were presented in the previous paper (Manigandan, 2007; Manigandan, 2008; Selvasekarapandian, 2000; Iyengar et al., 1990).

To determine the concentration of ^{210}P, about 30 g of dried samples were taken. To start with, the samples were digested with 4 N HNO_3 then with 8 N 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 (Iyengar et al., 1990; Anand and Rangarajan, 1990). Then it was counted in ZnS [Ag] alpha counter of background 0.2 cpm and efficiency 30%. Polonium-210 activity was estimated using the standard methods (Iyengar et al., 1990; Anand and Rangarajan, 1990).

RESULT AND DISCUSSION

The ^{210}Po and ^{238}U radioactivity concentration in Bq/kg dry weight are presented in Table 1 for soils and *E. roxburghiana* and in Table 2 for soils and *E. oblangus.* Values of concentration ratio (CR), defined as the ratio between the concentration (dry mass) of radionuclide in the plants and the concentration (dry mass) of the same radionuclide in the substrate, are given in the Tables 2.

Soils

The activity concentration of ^{210}Po up to 56 Bq/kg and ^{238}U up to 47 Bq/kg were found. The results of soil concentration reveal the secular equilibrium is attained between the ^{238}U and it's daughter product. The graph

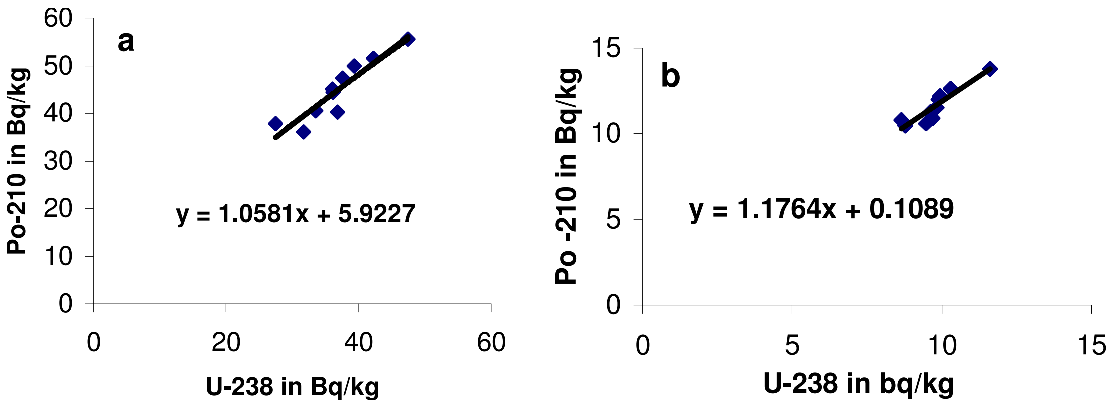

Figure 1. ^{238}U activity concentration vs ^{210}Po activity concentration in soil and in the plant samples.

shows the linear relation between ^{238}U and its daughter product with the regression of 0.93 (Figure 1a). Activity of daughter product is slightly higher than the U. The same was observed by Mordberg et al. (1976), Sheppard (1985) and Martinez-Aquirre and Garcia-leon (1997).

Plants

The same radionuclides were analysed in samples of *E. oblangus* and *E. roxburghiana* whose results are very similar, ranging from 9.19 to 13.80 Bq/kg for ^{210}Po and 8.51 to 11.62 Bq/kg for ^{238}U with the activity concentration of ^{210}Po being higher than the U in most of the samples. In generally the highest radioactivity concentration in plants are found in those collected in area with the highest radioactive concentration in the soil substrate and the lowest in those with lowest concentration in the substrate.

It does seem interesting to study the relationship between these radionuclides. In Figure 1b radioactive concentrations of U versus its daughter product ^{210}Po is plotted. The linear relationship can be found between the concentration of ^{210}P and ^{238}U in the plants [regression of 0.923 and 0.852]. But values of activity concentration in *E. roxburghiana* are slightly higher than the *E. oblangus* , this may lead to the conclusion that different plant species uptake the different amount of radionuclides depending on the substrate concentration, nature of the plants and ageing of the plant where as the soil type and climate condition in which the plant growing are same.

Comparing the U concentration in the plants, Y intercept of this line [0.1089] is clearly different from zero. This Y intercept reflects the variation in the ^{210}Po/^{238}U activity ratio with the U concentration in the plant. Thus, for a low U concentration [back ground level], there is slight excess of ^{210}Po compare to U. This excess decreases to secular equilibrium for the high U concentrations. In fact, for plants with enhanced concentration, both radionuclides are practically in secular equilibrium Sheppard (1985) and Martinez-Aquirre and Garcia-leon (1997).

Concentration ratios (CR)

Tables 1 and 2, gives the CR values obtained for *E. oblangus***,** for U and Po and its range varies from 0.244 to 0.321 and 0.198 to 0.241, respectively and same for *E. roxburghiana* 0.250 to 0.359 and 0.247 to 0.301, respectively. The CR value is higher for Po than U, its shows a greater transfer for Po to plant than U.

Comparing the CR values for both plants species, there seems to be a tendency for a higher CR in the case of *E. roxburghiana* than the *E. oblangus* for both radionuclides. It can be observed that CR depends on soil concentrations. In order to study the behavior of the concentration ratios for these radionuclides, concentration ratios versus the activity concentration at the radionuclide in the soil substrate (Cs) have been plotted in Figures 2 and 3. The CR values clearly decrease when the activity concentration in the substrate soil increases. In fact, the data can be modeled by fitting of the form.

$CR = a\,Cs^{b}$

Where *a* and *b* are parameters to be determined.

Thus, If *b* = 0, this would mean that the concentration ratio is constant, regardless of the activity concentration in the soil substrate. Functions of this type have been fitted for ^{238}U and ^{210}Po; the results are presented in Table 3. Thus for both radionuclides, the *b* value of hyperbolic function is clearly different from zero. Thus it seems that all these radionuclides follow the behavior of an essential for the plant growth. However, whether these elements are essential or are mimicking essential elements cannot be determined within this study.

Moreover, if activity concentration in the soil substrate very high, the CR value would be apparently constant. The same was observed Sheppard (1985), Timpereley et al. (1970) and Martinez-Aquirre and Garcia-leon (1997). Using the given data's in the Table 3, we can predict the plant concentration from the substrate concentration only those place with high activity concentrations in the soil

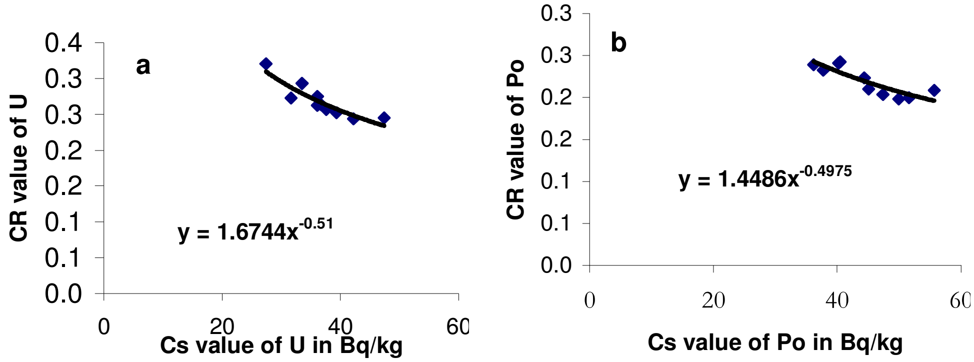

Figure 2. CR value vs. Cs of different radionuclides in soil for the plant of *E. oblangus*

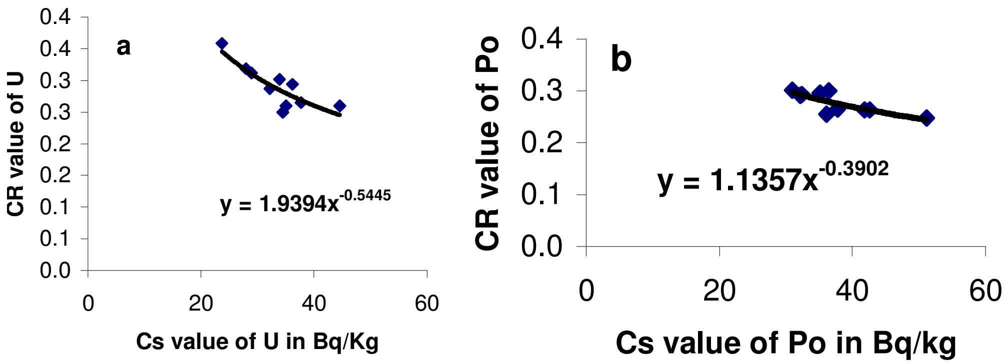

Figure 3. CR value vs. Cs of different radionuclides in soil for the plant of

Table 3. Relation between concentration ratios of both radionuclides in soil and plants.

Radionuclide	Eleaocarpus oblangus		Evodia roxburghiana	
	$CR = aCs^b$	Regression Coefficient *r*	$CR = aCs^b$	Regression Coefficient *r*
^{232}U	$CR = 1.674Cs^{-0.51}$	- 0.873	$CR = 1.939Cs^{-0.545}$	- 0.819
^{210}Po	$CR = 1.449Cs^{-0.4975}$	- 0.849	$CR = 1.136Cs^{-0.390}$	- 0.7834

substrate, thus *E. roxburghiana* and *E. oblangus* could be used as bio indicators to monitor the primordial nuclides in plants species in the forest ecosystem in the Western Ghats.

Conclusion

Concentration ratios for all radionuclides in 2 plants were determined. The concentration ratio of element seems to depend on the activity concentration of the same elements in its soil substrate. Thus, high CR appears in plant growing in soil with a low concentration. Moreover, the relation between the CR and the activity concentration of the soil substrate seems to be hyperbolic in all the cases. Thus we can predict activity concentration of these radionuclides in the plant from the substrate soil. CR values versus soil substrate graph for the both radionuclides, shows that all radionuclides behaves as an essential element at low Cs. In both plants, the CR value for both radionuclides seems to be constant in all the location with the higher substrate soil. Thus, it could be used as bio indicator to monitor both radionuclides in the plants at the Western Ghats region.

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