Iran. J. Radiat. Res., 2008; 5 (4): 195-202

Bio-indicators in the tropical forest of western Ghats environment

P.K. Manigandan[1*] and N.M. Manikandan[2]

[1] Dhafir Institute, Abu Dhabi, UAE
[2] Department of Physics, Bharathiar University, Coimbatore-641046, India

Introduction: Investigation on the natural radionuclides ^{238}U, ^{232}Th, ^{40}K and natural fallout radionuclide ^{210}Po in the prominent plants species of Western Ghats tropical forest near Kotagiri have been carried out as a part of baseline background radiation studies in the forest environment. ***Materials and Methods:*** The prominent plants species of the region *Evodia roxburghiana and Eleaocarpus oblangus* were chosen and concentrations of ^{238}U, ^{232}Th, ^{40}K and ^{210}Po were measured by employing gamma ray spectrometer and alpha counter. ***Results:*** The radioactivity concentrations in plants and soils 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 results shows that the concentration ratios (CR) seem to be depend on radionuclides in soil. ***Conclusion:*** From careful analysis of the results, these Plants could be used as an indicator to monitor these radionuclides. **Iran. J. Radiat. Res., 2008; 5 (4): 195-202**

Keywords: *Primordial radionuclides, Western Ghats, monazite, igneous rock, CR -concentration ratio.*

INTRODUCTION

Environmental assessment use food chain models to 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. Of many reviews published in this regard, Sheppard and Sheppard (1985) (1) observed a linear relation between the plant concentration and substrate concentration. Cannon (1952) (2) has stated that uranium (U) may be a micronutrient for higher plants, which means that CR was not linearly related to the substrate concentration. Mordberg *et al.* (1976) (3) 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) (4) and Mengel and Kirkby (1979) (5), 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 range. We have previously, shown that activity concentration of the ^{232}Th was high in the region of Western Ghats especially around the hill station Nilgiris due to the presence of monazite sand. Limited data's are available to evaluate the environmental radioactivity in these part of the region, therefore it was felt worthwhile to study radioactivity in some tropical forest plants so that indicators to 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 was to measure the concentration of primordial nuclides in soils and how they have been incorporated in the plants from their substrate concentration. Although these species are not directly involved in the human food chain, information on the

**Corresponding author:*
Dr. P. K. Manigandan., Dhafir Institute, Abu Dhabi, UAE.
Fax: *+971 2 627668*
E-mail: *pkmgs@yahoo.com*

concentration level and the transfer of radionuclides from contaminated soil will provide important data on the transfer mechanism in the case of those species more directly involved in the human diet.

MATERIALS AND METHODS

Sampling

Evodia roxburghiana and *Eleaocarpus 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 at four 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 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.

Gamma ray Spectrometer

The primordial radionuclides activities were estimated using NaI (Tl) spectrometer, which was coupled with TNI PCA II Ortec model 8K multichannel 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 energies 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/kg for ^{238}U series and 13.2Bq/kg for ^{40}K at 3σ confident levels. Details of the detector were presented in the previous paper [6-7]. 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 [8-12]. 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 [12].

RESULTS AND DISCUSSION

The activity concentration of primordial radionuclides and the fallout radionuclides were presented in the tables 1 and 2 for the plants of *Evodia roxburghiana* and *Eleaocarpus oblangus* collected from the long wood forest. 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 same tables.

Eleaocarpus oblangus

In soil: The results of soil concentration reveal the secular equilibrium is attained between the ^{238}U and its daughter product. The graph 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 [1.2 times] than the U. For different radionuclides graphs were drawn, all are linearly related with each other in the soil, but Y-intercept is clearly different from zero. This fact reflects that the ^{232}Th/^{238}U and ^{40}K/^{238}U activity ratio are not constant across the forest soil at Kotagiri. Therefore hyperbolic function is formed between the activity ratios versus ^{238}U concentration and it is represented in figure 1b and 1c. From the graph it observed that the activity ratio remains constant only for high concentration of ^{238}U in the soil, for the activity concentration low, contamination of

Table 1. Activity concentration of radionuclides in the *Eleaocarpus oblangus*.

Sample number	Activity concentration in Soil [Bq/kg]				Activity concentration in Plant [Bq/kg]				CR			
	Th-232	U-238	Po-210	K-40	Th -232	U-238	Po-210	K-40	Th-232	U-238	Po-210	K-40
1	78.46	36.09	45.13	193.19	16.69	9.47	10.60	181.32	0.213	0.262	0.210	0.939
2	62.57	36.77	40.22	202.76	15.21	9.70	10.92	176.98	0.243	0.264	0.241	0.873
3	82.66	47.41	55.63	254.01	18.12	11.62	13.80	198.01	0.219	0.245	0.209	0.780
4	75.95	36.10	44.40	187.8	17.08	9.93	12.18	170.45	0.225	0.275	0.224	0.908
5	70.52	33.56	40.53	182.37	16.04	9.83	11.54	167.01	0.227	0.293	0.243	0.916
6	53.47	31.66	36.15	189.54	15.83	8.64	10.79	173.64	0.296	0.273	0.239	0.916
7	55.15	27.42	37.79	180.54	18.48	8.79	10.46	160.23	0.335	0.321	0.233	0.888
8	74.28	37.57	47.39	222.04	17.87	9.64	11.27	196.57	0.241	0.256	0.203	0.885
9	77.26	42.26	51.61	234.42	17.82	10.30	12.61	188.23	0.231	0.244	0.199	0.803
10	67.82	39.31	49.92	230.1	16.2	9.90	11.99	183.43	0.239	0.252	0.198	0.797

Table 2. Activity concentration of radionuclides in the *Evodia roxburghiana*.

Sample number	Activity concentration in Soil [Bq/Kg]				Activity concentration in plant [Bq/Kg]				CR			
	Th-232	U-238	Po-210	K-40	Th-232	U-238	Po-210	K-40	Th-232	U-238	Po-210	K-40
1	64.96	34.47	36.11	203.90	12.61	8.60	9.19	190.00	0.194	0.250	0.254	0.932
2	49.07	28.00	32.21	202.76	12.41	8.92	9.40	188.20	0.253	0.319	0.292	0.928
3	77.66	44.58	51.15	253.81	16.33	11.59	12.64	206.79	0.210	0.260	0.247	0.815
4	62.45	32.18	35.11	186.89	14.30	9.25	10.38	180.30	0.229	0.287	0.296	0.965
5	57.02	35.05	37.77	192.27	13.28	9.11	9.98	183.92	0.233	0.260	0.264	0.957
6	53.47	28.93	32.40	156.74	13.97	9.01	9.49	150.20	0.261	0.311	0.293	0.958
7	44.65	23.72	31.04	170.54	11.99	8.51	9.34	160.26	0.269	0.359	0.301	0.940
8	74.28	37.72	42.58	202.40	16.23	9.99	11.24	190.71	0.219	0.265	0.264	0.942
9	67.12	36.18	41.88	213.72	15.95	10.63	11.04	199.12	0.238	0.294	0.264	0.932
10	64.53	33.87	36.45	210.01	15.18	10.21	10.93	198.15	0.235	0.301	0.300	0.944

radionuclides from the ^{232}Th decay and K seems to be undistinguished. The same was observed by Mordberg *et al.* (1976) (3), Sheppard (1985) (1), Martinez-Aquirre and Garcia-Leon (1997) (13).

The activity concentration of ^{232}Th is higher [1.9 times] than ^{238}U decay chain. Similarly, the concentration ^{40}K are also much higher [5.6 times that of ^{238}U and 3 times that of ^{232}Th] than the rest of the radionuclides.

In plants: The same Radionuclides were analysed in samples of *Eleaocarpus oblangus* whose results are presented in table 1. The activities range, in general from 10.46 to 13.80Bq/kg for ^{210}Po and 8.64 to 11.62Bq/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.

Concentration ^{232}Th is clearly much higher than those of the ^{232}U decay chain [15.21 to 18.48Bq/kg for ^{232}Th]. Even though the mobility of ^{238}U decays chain is higher than the ^{232}Th, the higher concentration of ^{232}Th in the plants due to the impact of the igneous type rock presented in the study area [Monazite].

It does seem interesting to study the relationship between these radionuclides. In figure 2a radioactive concentrations of U versus its daughter product ^{210}Po is plotted.

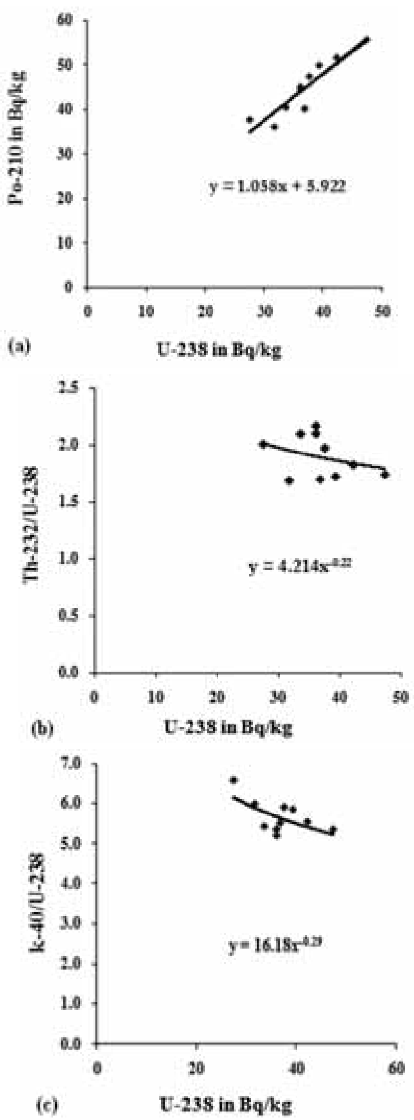

Figure 1. Relation between the activity concentrations of U-238 and different radionuclides (a, Po-210; b, Th-232; c, K-40) in soil.

The linear relationship can be found between the concentration of ^{210}P and ^{238}U in the plants [regression of 0.923]. 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) [1], Martinez-Aquirre and Garcia-Leon-(1997) [13].

More interesting seems to be the relationship of the ^{232}Th and ^{40}K concentration with ^{238}U concentrations figure 2b and 2c. The concentration of ^{232}Th and ^{40}K in plants clearly increases as concentration of U increases, following linear relationships.

Evodia roxburghiana

The same study has been carried out in the plants of *Evodia roxburghiana*. The results are presented in table 2. From the table it's clear that the activity concentration of radionuclides in the soil and uptake of radionuclides by plant *Evodia roxburghiana* is following the similar trend of *Eleaocarpus*

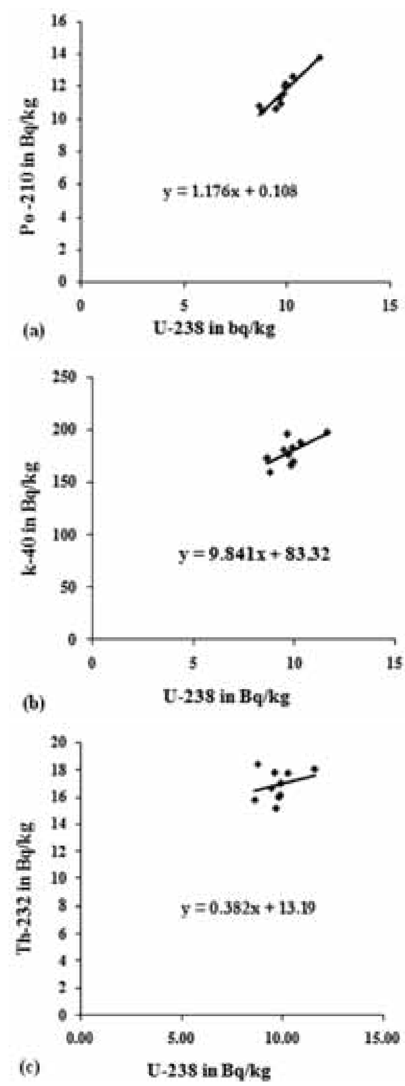

Figure 2. Relation between the activity concentration of U-238 and different radionuclides (a, Po-210; b, K-40; c, Th-232) in *Eleaocarpus oblangus* samples.

oblangus.

In soil: The activity of U, Po, Th and K varies within the soil 23.72 to 44.58Bq/kg, 31.04 to 51.15 Bq/kg, 44.65 to 77.66Bq/kg and 156.74 to 253.81 Bq/kg, respectively. Figure 3a shows the linear relationship between U and daughter product. For different radionuclides graphs were drawn, all are linearly related with each other in the soil. Since the y intercept is clearly different from zero, hyperbolic function is formed between the ratio of Th/U and K/U with activity concentration of U and it's shown in the figure 3b and 3c. These activity ratios seem to remain constant only for ^{238}U above some 30Bq/kg.

In plants: The same in the plants are in the range of 8.51 to 11.59 Bq/kg, 9.19 to 12.64 Bq/kg, 11.99 to 16.33 Bq/kg and 150.20 to 206.79 Bq/kg for U, Po, Th, and K respectively. The linear relationships are found between the radionuclides in the plant and are shown in the figure 4a. But their values are slightly higher than the former one [*Eleaocarpus 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.

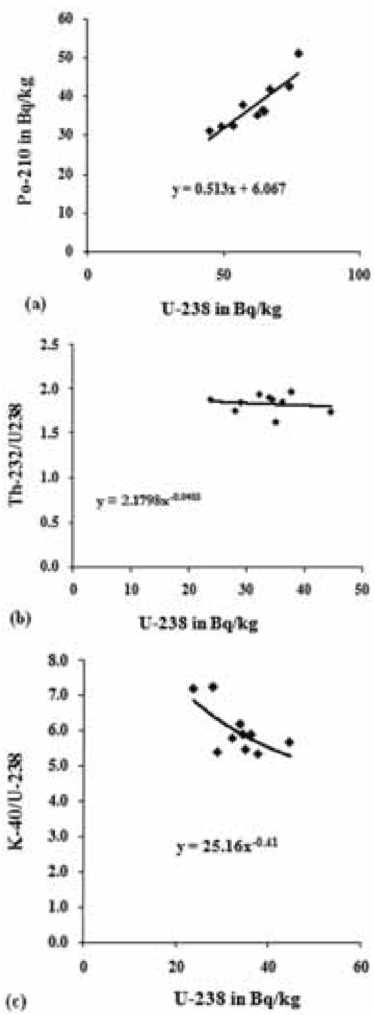

Figure 3. Relation between the activity concentrations of U-235 with different radionuclides (a, Po-210, b, Th-232; c, K-40) in soil samples.

Concentration Ratio:

Tables 1 and 2, gives the CR values obtained for *Eleaocarpus oblangus*, for U, Po, Th and K and its range varies from 0.244 to 0.321, 0.198 to 0.241, 0.213 to 0.355 and 0.797 to 0.939 respectively and same for *Evodia roxburghiana* 0.250 to 0.359, 0.247 to 0.301, 0.194 to 0.269 and 0.815 to 0.958 respectively. The CR value is higher for K than rest of radionuclides, its shows a greater transfer for K to plant than that of the rest.

Comparing the CR values for both plants species, there seems to be a tendency for a higher CR in the case of *Evodia roxburghiana* than the *Eleaocarpus oblangus* for all radionuclides expect ^{232}Th. 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 figure 3b and c, for ^{238}U, ^{232}Th and ^{40}K. 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 ^{210}Po, ^{238}U, ^{232}Th and ^{40}K and the results are shown in figures 5 and 6 (a-d).

Thus for all radionuclides from the ^{238}U,

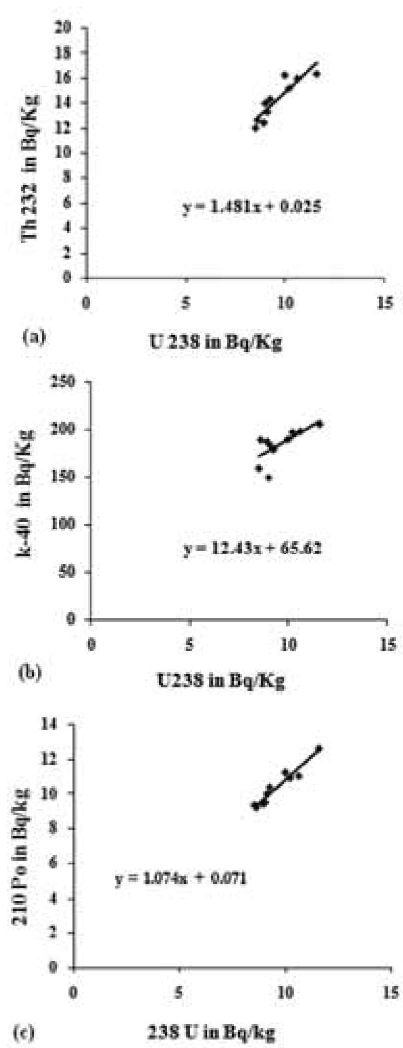

Figure 4. Relation between the activity concentrations of U-235 with different radionuclides (a, Th-232, b, K-40; c, Po-210) in *Evodia roxburghiana* samples.

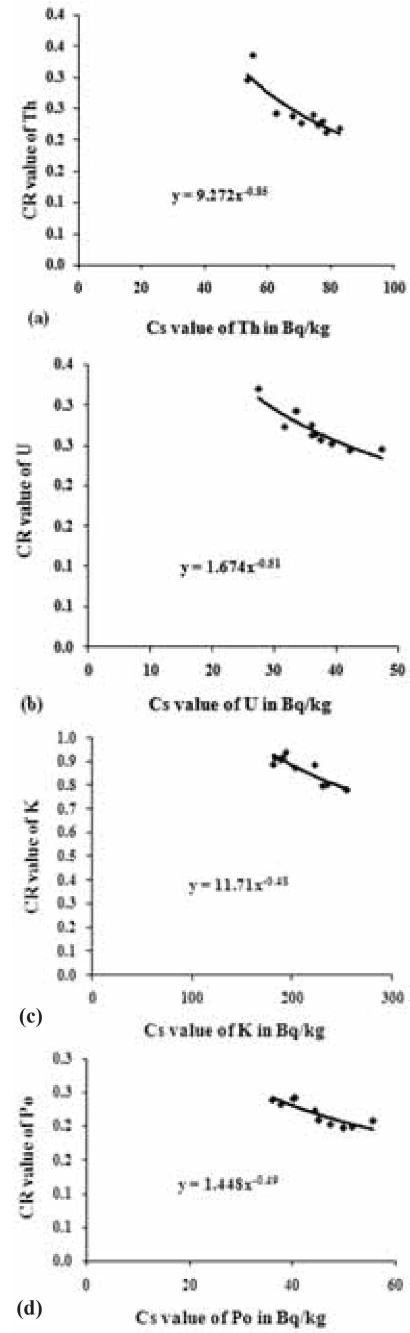

Figure 5. CR value versus Cs of different radionuclides (a, Th; b, U; c, K; d, Po) in soil for the plant of *Eleaocarpus oblangus.*

^{210}Po, ^{232}Th and ^{40}K, 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) (1), Timpereley, *et al.* (1970) (4) and Martinez-Aquirre and Garcia-Leon (1997) (13). Using the given data's in the table 3, we can predict the plant concentration from

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

Radionuclide	Eleaocarpus oblangus		Evodia roxburghiana	
	CR = aCs^b	Regression Coefficient r	CR = aCs^b	Regression Coefficient r
232Th	$CR=9.272Cs^{-0.8583}$	-0.869	$CR=1.434Cs^{-0.443}$	-0.775
232U	$CR=1.674Cs^{-0.51}$	-0.873	$CR=1.939Cs^{-0.545}$	-0.819
210Po	$CR=1.449Cs^{-0.4975}$	-0.849	$CR=1.136Cs^{-0.390}$	-0.7834
40K	$CR=11.71Cs^{-0.4883}$	-0.890	$CR=4.082Cs^{-.2797}$	-0.812

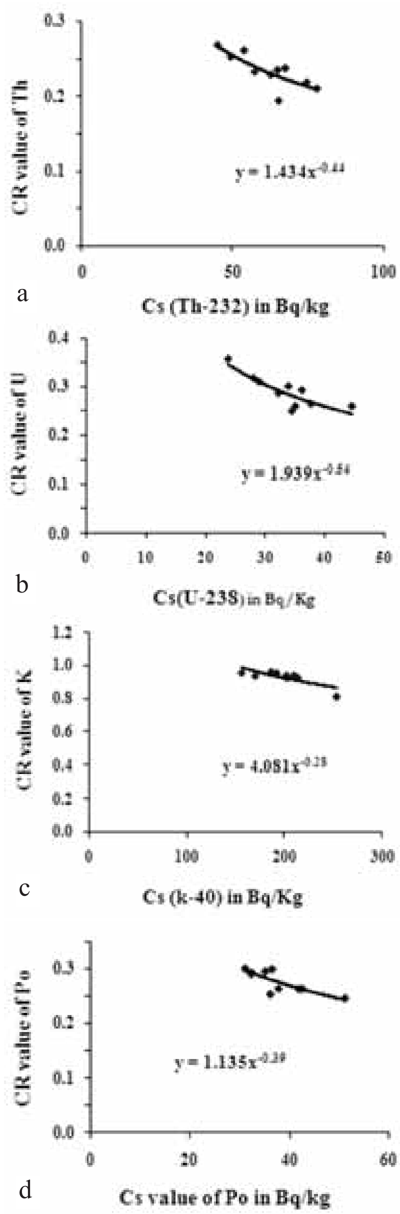

Figure 6. CR value versus Cs of different radionuclides (a, Th; b, U; c, K; d, Po) in soil for the plant of *Evodia Roxburghiana*.

the substrate concentration only those place with high activity concentrations in the soil substrate, thus *Evodia roxburghiana* and *Eleaocarpus 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 two 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 different radionuclides, shows that all radionuclides behave as an essential element at low Cs. In both Plants, the CR value for all 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 primordial and natural fall out nuclides in the plants at the Western Ghats region.

ACKNOWLEDGEMENT

The authors are thankful to Dr. A. Natarajan, Head, HASL, IGCAR, Dr. A.R. Lakshmanan. HASL, IGCAR and Dr. A.R. Iyengar, Head, ESL, Kalpakkam for their constant encouragement throughout the period of this work.

REFERENCES

1. Sheppard I and Sheppard SC (1985) The plant/ soil concentration ratio concept as applied to natural U. *Health Physics, **48**: 494-500.*
2. Cannon ML (1952) The effect of uranium vanadium deposited on the vegetation of the Colorado plateau. *Am J Sci, **250**: 735-70.*
3. Mordberg EA, Aleksandruk V M, Kovygin G F, Shevchenkov II (1976) Translocation of isotopes of the uranium-radium series into the grain of certain agricultural crops. *Journal Gigiena I Sanitariia, **2**: 58-61.*
4. 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.*
5. Mengel K and Kirkby EA (1979) Priciples of plant nutrition (2nd Edn). International Potash Institute, Bern, Switzerland.
6. Manigandan PK (2007) Distribution of Radionuclides in the Forest soils (Western Ghats -India). *Iranian Journal of Radiation Research **5**: 17-22.*

7. Selvasekarapandian S, Muguntha Manikandan N, Sivakumar R (2000) Natural radiation distribution of soil at Kotagiri Taluk of Nilgiris biosphere in India. Eighth International Conference, October 16-20, 2000, Ibaraki, Japan.
8. Berger KC, Erhardth WH, Francis CW (1965) 210Po analysis of vegetables cured and uncured tobacco and associated soil. *Science* ***150**: 1738-9.*
9. Abe S and Michiko A (1973) Chemical properties of 210Po in the atmosphere: Proc Symp. *IAEA-SM,* ***181**: 367-73.*
10. Khandekar RN (1977) Polonium-210 in Bombay diet. *Health Phys,* ***33**: 150-4.*
11. Anand SJS and Rangarajan C (1990) Studies on the activity ratio of 210Po to 210Pb- and their dry deposition velocities at Bombay in India. *Journal Environmental Radioactivity,* ***11**: 235-50.*
12. Iyengar MAR, Ganapathy S, Kannan V, Rajan MP, Rajaram S (1990) Procedure Manual, Workshop on Environmental Radioactivity, Kiga, India.
13. Martinez-Aquirre A, Garcia-Orellana L, Garcia-Leon M (1997) Transfer of Natural radionuclides from soils to plant in a marsh enhanced by the operation of non-nuclear industries. *Journal Environmental Radioactivity* ***35**: 149 -171.*