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Activity Distribution and Uptake of Radionuclides in Medicinal Plants of Coastal Karnataka, India

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Abstract

Primordial Use of medicinal plants as therapeutic agents is an age-old practice. The detailed studies on the concentration of radionuclides in medicinal plants are sparse. The medicinal plants Justica adhatoda L., Careya arborea Roxb., Mimosa pudica L., Azadirachta indica A Jus. and Plectranthus amboinicus (Lour.)Spreng. are selected in the present study. These plants and soil samples from same location were analysed for activity concentrations of ^{226}Ra, ^{210}Pb, ^{232}Th, ^{40}K and ^{137}Cs using gamma spectrometry. The activity concentrations of ^{226}Ra, ^{210}Pb, ^{232}Th and ^{40}K in plant samples vary in the range of BDL to 9.59 $BqKg^{-1}$, 9.07 to 320.34$BqKg^{-1}$, BDL to 6.40 $BqKg^{-1}$ and 443.50 to 3401.29 $BqKg^{-1}$ respectively. The concentration of ^{137}Cs was found to be BDL for all the plant samples. Soil samples were analysed for the above listed radionuclides and the soil to plant transfer factors were also estimated. The transfer factors found to vary from BDL to 0.17 for ^{226}Ra, 0.12 to 3.73 for ^{210}Pb, BDL to 0.068 for ^{232}Th and 2.94 to 28.66 for ^{40}K. The detailed results and discussions are presented in this paper.

Keywords: Medicinal plants, therapeutic agents, radionuclides, plant uptake, transfer factors.

Introduction

Ayurveda is one of the most important methods of therapy used in almost all parts of the world. Many dynasties across the world have played significant role in the development of this method of treating the diseases. Use of medicinal plants as therapeutic agents is an age-old practice. The nature around us is diverse and it is treasure house of variety of biodiversity including plants used in treating for some ailments in human beings and animals. The popularity and use of medicinal plants as alternate medicines is significantly high in this region. Several documents are available listing the plants for their medicinal values in literature[1]. Several studies in different regions have been made to know the basic contents of the plants[2,3]. West coast regions of Karnataka are known for using traditional and folklore medicine in which medicinal plants are used as main ingredients. The detailed studies on radionuclides in these plants are sparse in this geographical area.

The developmental activities, industrialisation and associated technological endeavours have resulted in increased encroachment and pollution of nature. In addition to the naturally occurring radionuclides, essential and heavy elements; artificially produced and technologically enhanced concentrations of these elements also will be taking place due to activities listed above. All these activities cause contamination of radionuclides, toxic elements and other polluting agents on vegetation[4]. Studies on transfer of natural radionuclides from soil-to-plant have been carried out in various regions world over to understand the nature of absorption and accumulation of radioactive and non-radioactive elements[5-11]. From soil samples radionuclides are usually transferred to plant tissues by direct transfer via the root system, or by absorption of fallout radionuclides and resuspension of contaminated soil followed by deposition on plant leaves[5,12,13]. In addition to the well-known 16 essential elements for the growth and reproduction of plants, a number of other natural radioactive elements like uranium, thorium and their progeny, cosmogonic radionuclide ^{7}Be and artificial radionuclides such as ^{137}Cs and ^{90}Sr are found to be present in plants for different extents[14,15].

Coastal Karnataka is a region in which industries have been setup. Thermal power plant near Padubidri, Mangalore, Oil Refineries and Mangalore Chemicals and fertilisers in Mangalore are some of the major industries setup in this region. The agricultural crops such asareca nut, coconut, paddy and vegetables, cashew and spices are grown in this region.

This study aims at the analysis of radionuclides concentration in medicinal plants with different curative properties of this region. The plants *Justica adhatoda* L., *Careya arborea* Roxb., *Mimosa pudica* L., *Azadirachta indica* A Jus. and *Plectranthus amboinicus* (Lour.) Spreng. are selected and different parts of these plants used in medicine are collected in present study. These plants have got very high medicinal value and they are extensively being used in this region for treating different ailment[16].

Materials and Methods

Puttur (12.77°N and 75.22°E) is a small town in coastal Karnataka region of south India, situated at a height of 87m from

the sea level. Ayurvedic and traditional systems of medicine is extensively practiced in this region. This region also forms the part of the Western Ghats and good numbers of medicinal plants are available. Samples from this geographic region are collected in the present study. The common and scientific names of the plants, medicinal properties and parts of the plant used as medicine are presented in table -1.

The plants and soil samples from the selected area were collected. These samples were processed in accordance with the standard methods (EML procedure manual, 1983) and analyzed for ^{226}Ra, ^{210}Pb, ^{232}Th, ^{40}K and ^{137}Cs concentrations[17]. All the above listed radionuclides were estimated using HPGe gamma spectrometer[18]. The spectrometer was calibrated using standards obtained from IAEA. The soil-to-plant transfer factor (T.F.) is calculated using the following formula[19].

T.F. =Activity of radionuclide in plant sample (Bq Kg^{-1}dry weight) /Activity of radionuclide in soil sample (BqKg^{-1}dryweight)

Results and Discussion

The activity concentrations of the radionuclides ^{226}Ra, ^{210}Pb, ^{232}Th, ^{40}K and ^{137}Cs were measured in the medicinal plants listed above and also in soil samples collected from the corresponding sampling locations and the results are presented in table -2. The detectable level values for the activity concentration of ^{226}Ra, ^{210}Pb, ^{232}Th, ^{40}K and ^{137}Cs are 0.62, 0.77, 2.46, 1.42 and 0.09 $BqKg^{-1}$respectively. Activity concentrations of radionuclides less than the corresponding detectable levels are termed as below detectable level (BDL).

Table-1
Medicinal property of the plants

Medicinal Plant		Medicinal Property	Parts used
Common name	**Scientific name**		
Adusoge	*Justica adhatoda* L.	Bechic, Anti asthmatic and Expectorant	leaves
Daddala	*Careya arborea*Roxb.	Remedy in ulcer	leaves
Lajja	*Mimosa pudica* L.	Remedy in uterine disorders, wounds, leprosy etc.	whole plant
Neem	*Azadirachta indica* A Jus.	Anti diabetic, Antiseptic	leaves
Sambrani	*Plectranthus amboinicus* (Lour.)Spreng.	Diuretic, Antipyretic	leaves

Table-2
Activity Concentration and transfer factors of radionuclides

Plant	Quantity	^{226}Ra	^{210}Pb	^{232}Th	^{40}K	^{137} Cs
Justica adhatoda	Activity in soil ($BqKg^{-1}$)	40.47±5.54	46.07±6.05	100.46 ±3.18	147.84±8.67	2.96±0.63
	Activity in plant ($BqKg^{-1}$)	1.53±0.17	34.03±3.11	BDL	962.41±69.33	0.15±0.08
	T.F.	0.037	0.73	BDL	6.50	0.05
Careya arborea	Activity in soil ($BqKg^{-1}$)	41.79±4.17	46.17±5.53	103.36±3.02	131.11±8.32	4.06±0.56
	Activity in plant ($BqKg^{-1}$)	1.93±0.54	119.07±10.08	6.40±0.47	476.77±34.86	BDL
	T.F.	0.04	2.57	0.06	3.63	BDL
Mimosa pudica	Activity in soil ($BqKg^{-1}$)	45.69±5.05	36.15±5.81	89.58±3.27	150.74±9.43	3.77±0.63
	Activity in plant ($BqKg^{-1}$)	0.86±0.55	52.74±4.88	BDL	443.50±32.90	BDL
	T.F.	0.01	1.45	BDL	2.94	BDL
Azadirachta indica	Activity in soil ($BqKg^{-1}$)	58.28±3.50	75.00±9.13	155.29±3.82	142.27±9.10	0.91±0.56
	Activity in plant ($BqKg^{-1}$)	7.78±0.35	9.07±1.49	BDL	722.04±52.32	BDL
	T.F.	0.13	0.12	BDL	5.07	BDL
Plectranthus amboinicus	Activity in soil ($BqKg^{-1}$)	56.37±5.67	85.86±7.13	63.31±2.47	118.64±7.63	5.21±0.55
	Activity in plant ($BqKg^{-1}$)	9.59±0.97	320.34±27.92	4.36±1.42	3401.29±247.21	BDL
	T.F.	0.17	3.73	0.06	28.66	BDL

The results presented in column 3 shows that the concentration of ^{226}Ra in plants varies in the range of BDL to 9.59±0.97BqKg^{-1}.The maximum activity of ^{226}Ra was found in *Plectranthus amboinicus* plant (9.59±0.97BqKg^{-1}). In soil samples collected from the same area, it varies from 40.47±5.54BqKg^{-1} to 58.28±3.50BqKg^{-1}. The maximum activity is found in the soil corresponding to *Azadirachta indica*. The soil-to-plant transfer factor for this radionuclide is found to vary from BDL to 0.17.

The activity concentrations of ^{210}Pb in plants are presented in column 4 and it varies from 9.07±1.49 BqKg^{-1} to 320.34±7.92BqKg^{-1}. The plant *Plectranthus amboinicus* shows higher concentration (320.34±7.92BqKg^{-1}) compared to other plants. The activity concentration in soil varies from 36.15±5.81 to 85.86±7.13BqKg^{-1} with maximum activity corresponding to *Plectranthus amboinicus*. The average area of leaves is about 25 cm^2, slightly thicker with hair like structure and its surface morphology is rough. This may help in trapping atmospheric deposition and absorption through leaf as one of the routes for higher concentration of ^{210} Pb in leaves .The soil to plant transfer factors found to vary from 0.12 to 3.73. The higher value of TF in leaves show that the main contribution is from atmospheric deposition on leaves and subsequent absorption.

The ^{232}Th activity in plants (column 5) varies between BDL and 6.40±0.47BqKg^{-1}. In *Careya arborea*, activity of ^{232}Th is found to be maximum (6.40±0.47BqKg^{-1}). In soil samples ^{232}Th activity is found to vary from 63.31±2.47 to 155.29±3.82BqKg^{-1}. The maximum activity for this radionuclide is found in the soil corresponding to *Azadirachta indica*. The transfer factors for this radionuclide are found to vary from, BDL to 0.068.

The activity concentration of ^{40}K in plants (column 6) varies between 443.50± 32.90 to 3401.29±247.21 BqKg^{-1} with its maximum value in *Plectranthus amboinicus* (3401.29±247.21 BqKg^{-1}). The activity of ^{40}K in soil varies from 118.64±7.63 to 150.74±9.43BqKg^{-1} with its maximum value for *Mimosa pudica*. Transfer factors found to vary from 2.94 to 28.66.

The concentration of ^{137}Cs is tabulated in column 7 and found to be BDL for all the plant samples. In soil samples ^{137}Cs activity varies from 0.91±0.56 to 5.21±0.55BqKg^{-1} and the maximum activity is found in the *Plectranthus amboinicus* soil (5.21±0.55BqKg^{-1}).

Table-3
Comparison of Transfer factors with literature values

Radionuclide	T.F.	Plant	Reference
^{226}Ra	BDL- 0.17	plants under this study	Present study
	BDL	Tamarindus indica	[19]
	0.001-0.403	wild plants	[25]
	0.19-0.73	35 different plants	[26]
	0.99-1.28	*Manihot esculenta*	[27]
	0.50-0.74	*Ipomoea batatas*	[27]
^{210}Pb	0.12-3.73	plants under this study	Present study
	0.37-1.4	leafy vegetable	[5]
	0.01-0.34	fruit vegetable	[24]
	1.47×10^{-3} - 3.86	fruit vegetable	[28]
	0.01-.35	Rice plant straw	[24]
^{232}Th	BDL- 0.06	plants under this study	Present study
	0.013-0.024	wheat	[9]
	0.09- 0.88	35 different plants	[26]
	0.15-0.61	*Manihot esculenta*	[27]
	0.73-1.4	*Ipomoea batatas*	[27]
	0.273	*Michelia nilagirica*	[29]
^{40}K	3.63- 28.66	Plants under this study	Present study
	1.14-1.96	*Careyaarborea* Roxb.	[19]
	8.9	spinach	[24]
	0.4- 8.8	Rice plant root	[24]
	1.10-1.29	*Manihot esculenta*	[27]
	3.0-3.5	*Ipomoea batatas*	[27]
^{137}Cs	BDL	Plants under this study	Present study
	BDL - 0.1	*Careya arborea* Roxb.	[19]
	0.2	Spinach	[24]
	0.03 - 0.44	Grass	[30]

The soil to plant transfer factors of ^{226}Ra, ^{210}Pb, ^{232}Th and ^{40}K are found to be maximum in *Plectranthus amboinicus*. The transfer factor values for ^{210}Pb are more than unity for all the plants except *Justica adhatoda* and *Azadirachta indica*. This may because of the fact that in addition to the availability of ^{210}Pb in soil there will be atmospheric fallout in the form of wet and dry precipitate. This deposition will be absorbed by the plant leaves in addition to uptake through the root system[20]. Accumulation of^{210}Pb by aerial parts of plants occurs mainly through atmospheric deposition and root uptake[21]. Higher concentration of ^{210}Pb has been observed by other researchers also[5,22].

In spite of higher concentration of ^{232}Th in soil samples, the higher concentration of ^{226}Ra in plants was observed. The radium dissolves readily in water compared to thorium; consequently it is being transported to the plant through absorption of water through root[20]. As a member of the alkaline earth metals, the isotopes of radium exhibit similar chemical properties as calcium (Ca) and magnesium (Mg) that are essential for the plant growth and nutrition. In place of Caand Mg, depending on its availability plants may take up the ^{226}Ra. However, the concentration of ^{40}K in all the plants is found to be orders of magnitude higher than the activities of ^{226}Ra, ^{210}Pb, ^{232}Th and ^{137}Cs. The higher concentration of ^{40}K in both medicinal and non medicinal plants is evident and similar results have been reported by other investigators[19,23,24]. Potassium is one of the important nutrients of the plants and ^{40}K being its isotope it is expected to be higher in its concentration.The transfer factors of this study are compared with literature and the comparative report is presented in table-3. Figure1-10 represent activity and transfer factors of radionuclides and figure -11 represent comparison of transfer factors in the plants under study.

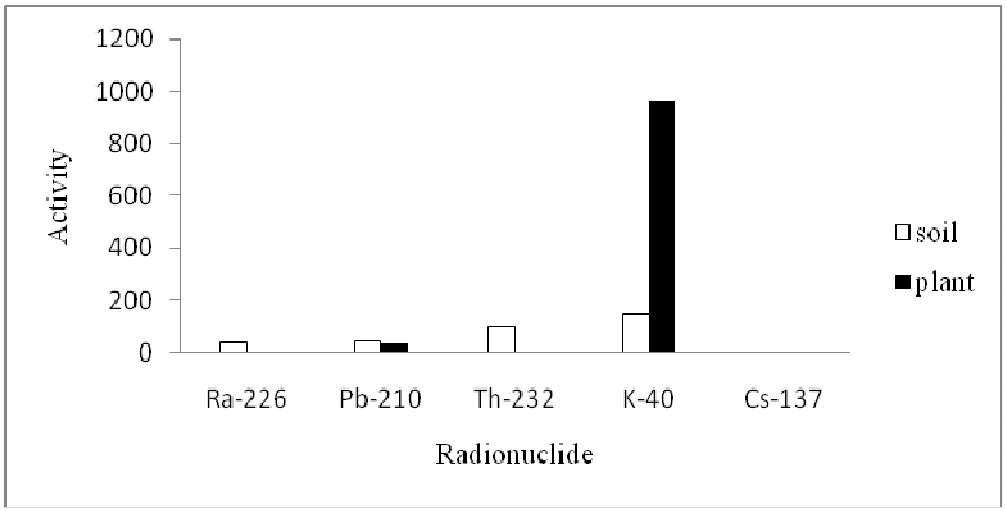

Figure-1
Activity in *Justica adhatoda*

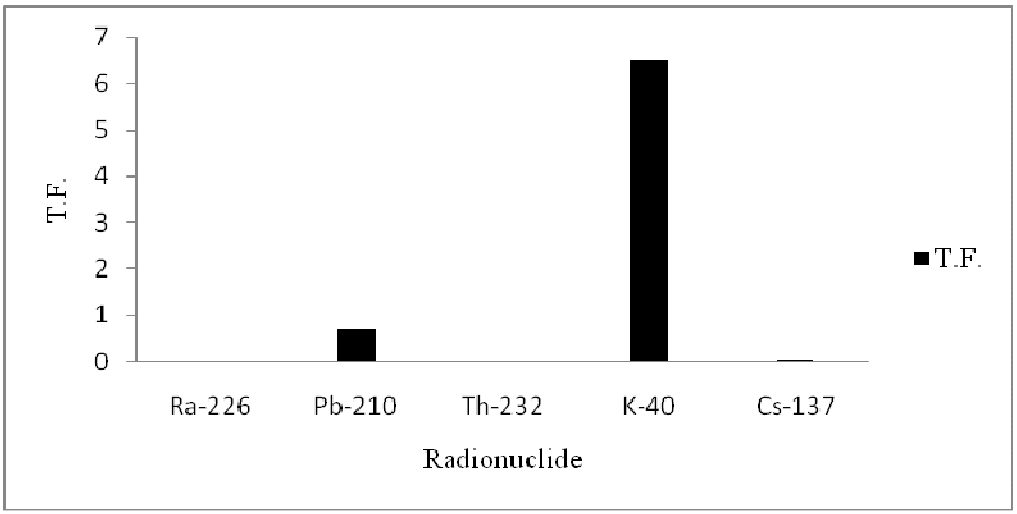

Figure-2
Transfer Factor in *Justica adhatoda*

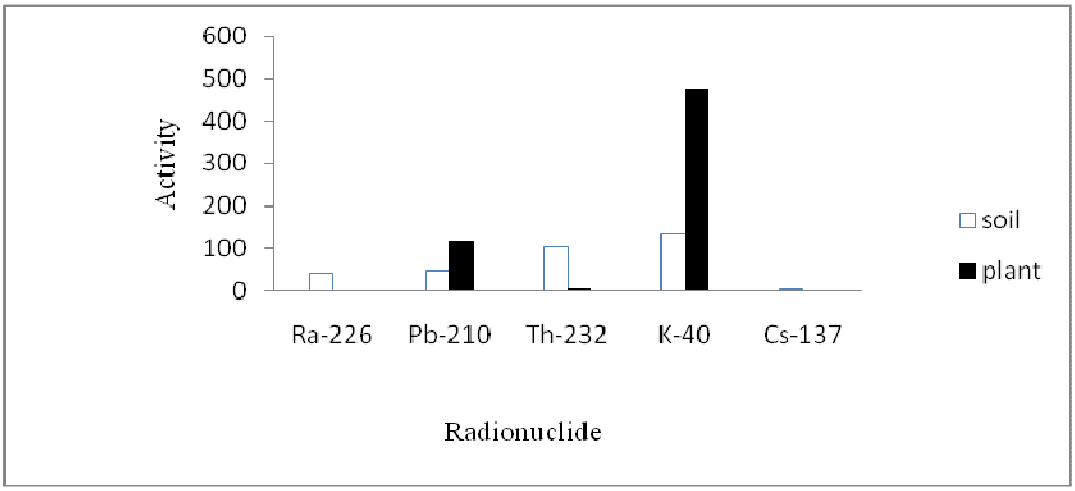

Figure-3
Activity in *Careya arborea*

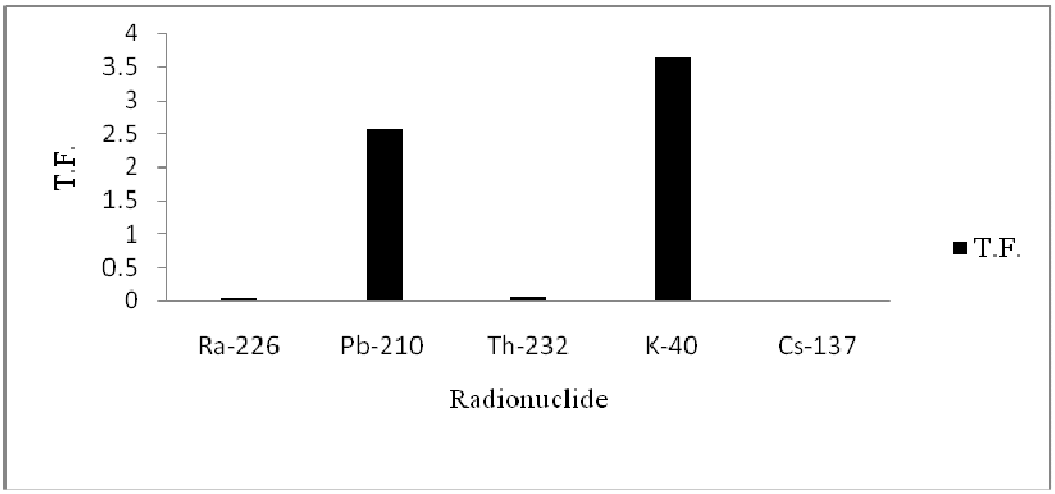

Figure-4
Transfer Factor in *Careya arborea*

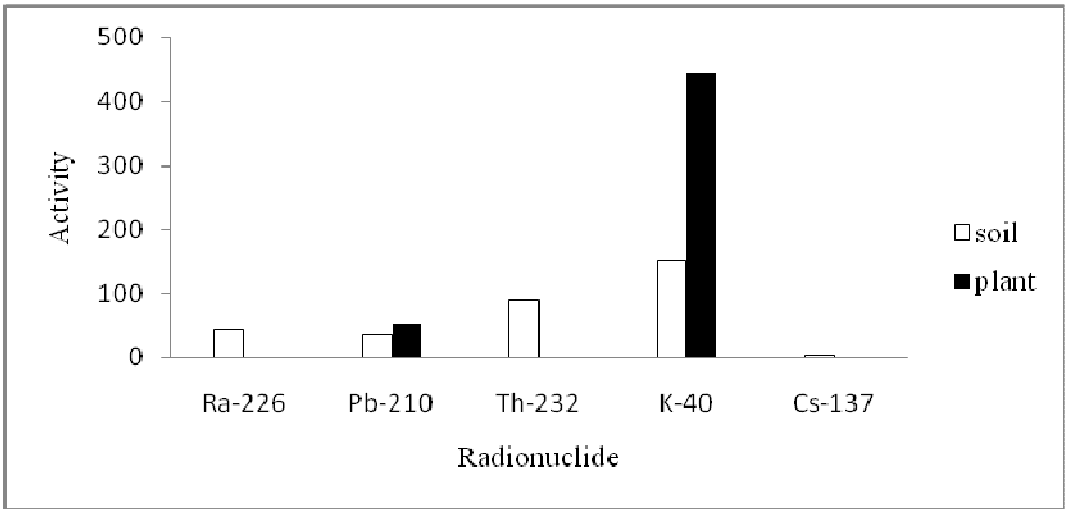

Figure-5
Activity in *Mimosa pudica*

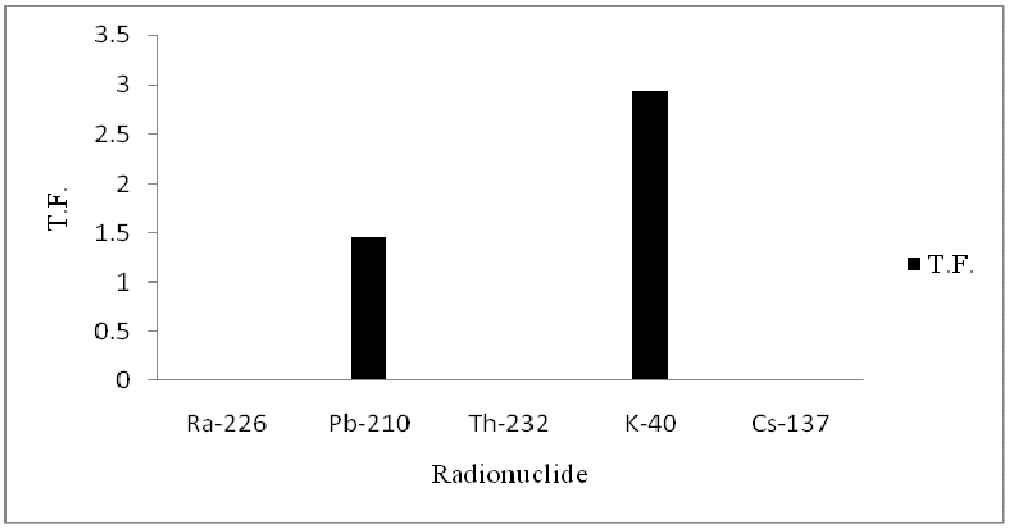

Figure-6
Transfer Factor in *Mimosa pudica*

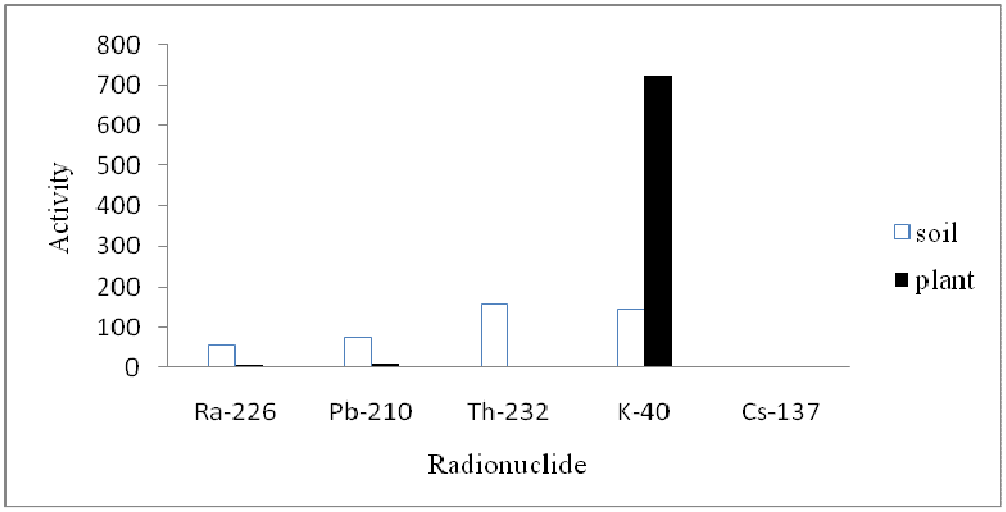

Figure-7
Activity in Azadirachta *indica*

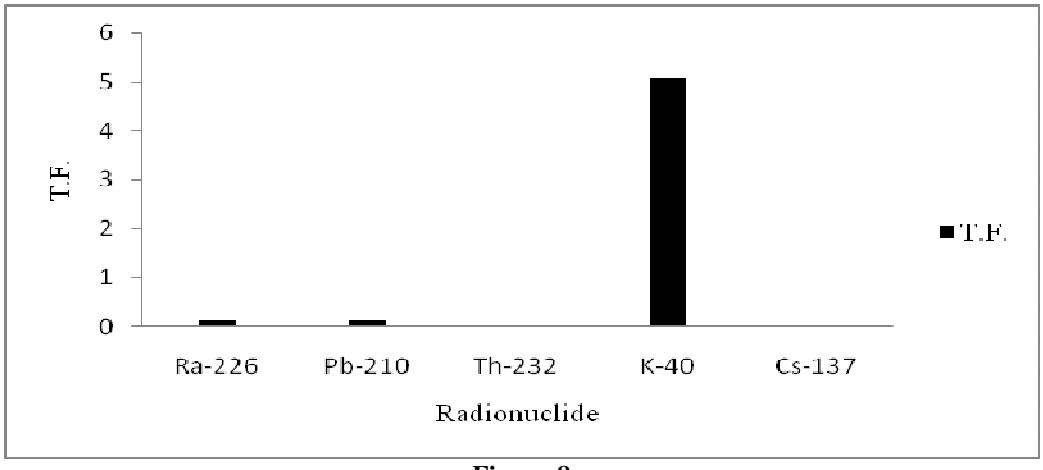

Figure-8
Transfer Factor in *Azadirachta indica*

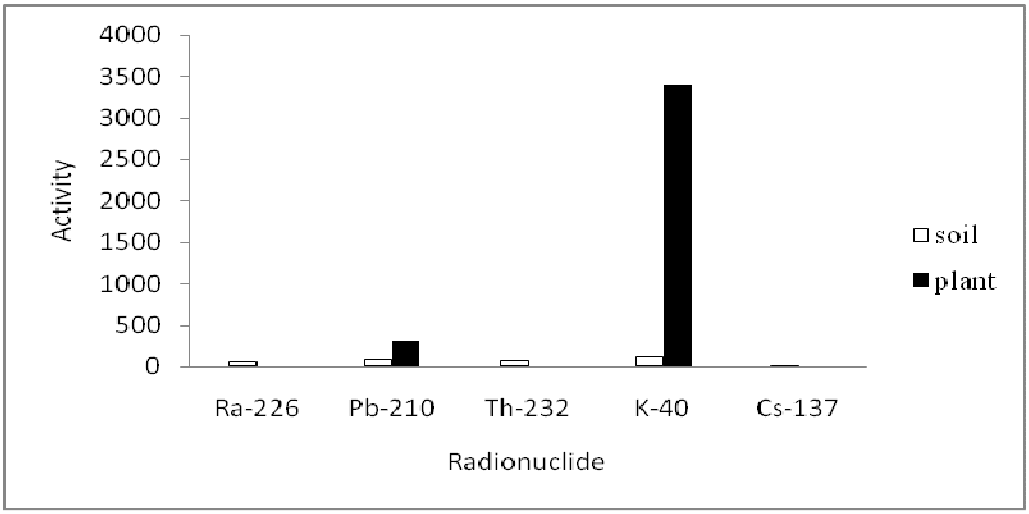

Figure-9
Activity in *Plectranthus amboinicus*

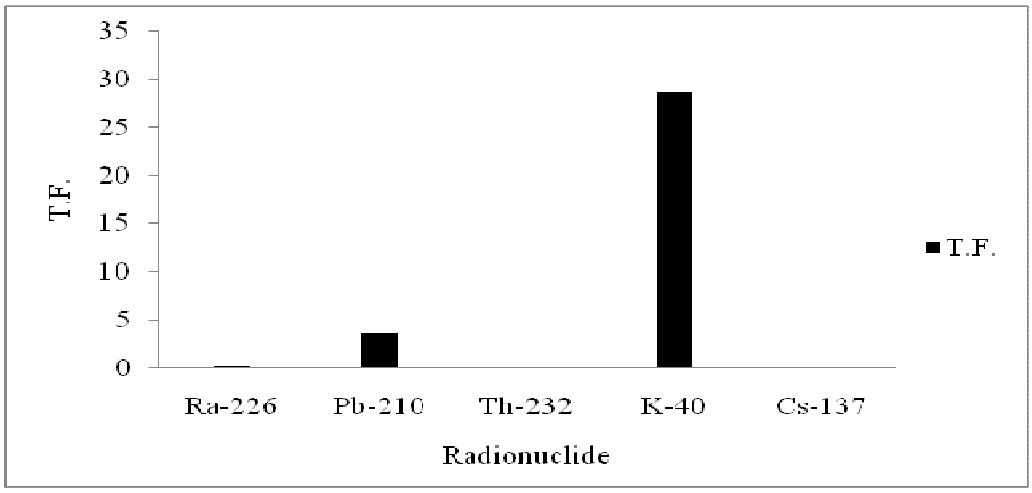

Figure-10
Transfer Factor in *Plectranthus amboinicus*

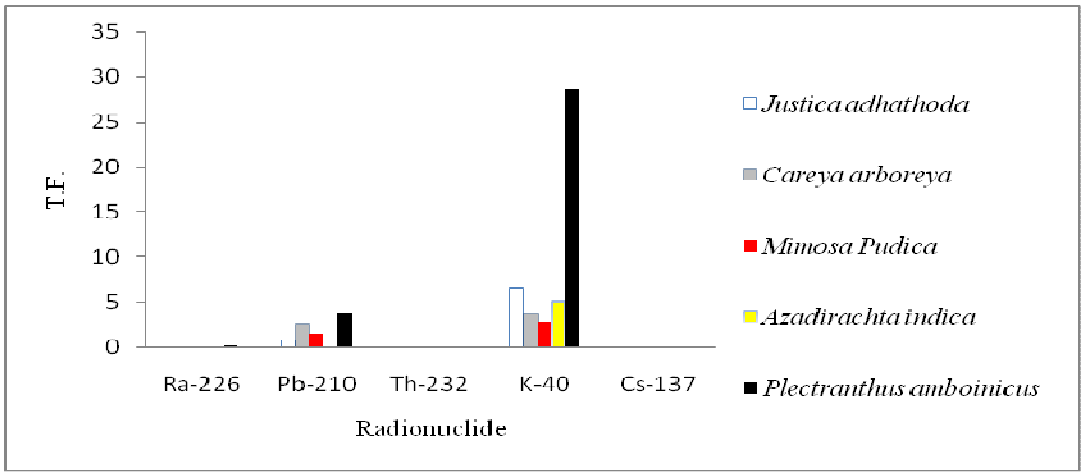

Figure-11
Comparisson of Transfer factors

Conclusion

The activity concentration of radionuclides and their transfer factors from soil to medicinal plants are presented and discussed in detail. This study proves the presence of activity concentration of certain radionuclides in medicinal plant species. The activities of ^{226}Ra, ^{210}Pb, ^{232}Th and ^{40}K are found be present quite significant in trace levels. Ithas been observed that the activity concentration and transfer factors for ^{40}K are higher than any other radionuclide. It has also been noticed that the activity concentration and transfer factor of above mentioned radionuclides is higher in *Plectranthus amboinicus* plant. It is quite natural that along with the medicines, these radionuclides also may be infused in to the human body. Either these radionuclides play their role in curing the diseases or else they may cause additional radiation dose to the population.

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