CONCENTRATION OF NATURAL AND ARTIFICIAL RADIONUCLIDES IN *MESUA FEREA* AUCT LINN - A MEDICINAL PLANT

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Abstract: The analysis and estimation of activity concentrations of natural and artificial radionuclides in different parts of *Mesua ferea* auct Linn., a naturally grown medicinal plant of coastal Karnataka in South India was carried out using a high resolution HPGe gamma spectrometer. The soil to bark, soil to leaves, and bark to leaves transfer factors (TF) of the radionuclides, average annual committed effective dose (AACED), and threshold annual consumption rate of medicinal plant were also estimated. It is found that the activity concentrations and transfer factors of ^{40}K were higher among all the estimated radionuclides, in both bark and leaves of *Mesua ferea*. The AACED due to consumption of bark and leaves, at a consumption rate of 1 kg/y, were found to be 0.0387±0.0032 mSv/y and 0.0423±0.0044 mSv/y respectively.These values are far below the world average of 0.3 mSv/y. Thus there is no health risk due to ingestion of radionuclides, if this medicinal plant is used to treat the diseases.

Key words: medicinal plant, Ayurvedic system, radionuclide, therapeutic use.

Introduction: The geological and geographical conditions of any region,influence the level of its radionuclide concentration, resulting in contamination of different short and long lived radionuclides on to the bio matrices of the world (UNSCEAR,2000).These radionuclides may be transported from one compartment of the environmental matrix to the other, through different environmental pathways. The soil-plant-man pathway of radionuclide transport was found to be an important pathway of its kind in which the radionuclides, absorbed by the plants from soil, reach man,because of the consumption of plants or their parts (IAEA, 1982).The data regarding concentration level and distribution of various natural and artificial radionuclides in any region,if estimated, becomes an important and useful document in building up the radiological safety regulations pertaining to that region.

The variety of biodiversity on earth, by its close association with the mankind, have played vital role, in its growth and progress.Moreover the plants and their parts have proved their efficacy to strengthen the health status of man, in significantly better way, across the world.It is a well-known fact that the therapeutic use of medicinal plants in human health is in regular practice even from Vedic period. The references to the curative properties of medicinal plants were also obtained from the ancient Indian literatures such as Charak samhitha and Sushrutha Samhitha, which are the important documents for Ayurvedic system of medicine.(Parchure, 1983 and Sharma, 1993).The medicinal plants are the main ingredients of Ayurvedic medicine and since are easily available for full of cheap, this system of medical therapy is more popular in coastal Karnataka. The traditional medicinal plants are known to have many essential and non-essential elements.The natural and artificial radionuclides present in the environment of earth are also found to be transported into plant matrix,according to the studies reported by many researchers across the world (Radhakrishna,1993; Somashekarappa et al., 1995;Karunakara, 1997;Lordfordet al.,2013; Al Masri et al.,2008 ;Njinga, et al., 2015).The radionuclides can enter into plants through root uptake from soil and by absorption of atmospheric deposition on plants. The root uptake depends on the activity concentration of these radionuclides present in the soil of root area of the plants and atmospheric absorption depends on the rate of radionuclide precipitation in the atmosphere. Uptake of some radionuclides occurs as the homologous of some essential elements and some are taken-up irrespective of their biological necessity (ChethanRao,2012).

Mesua ferea auct Linn., commonly known as Nagasampige, is a medicinal plant which is naturally grown in coastal Karnataka of South Indian region. The bark and leaves of this plant have very high medicinal value. The medicinal properties corresponding to different parts of plant used for curing the diseases are presented in Table-1.The detailed study of activity concentrations of various natural and artificial radionuclides and the soil to plant transfer factors of this medicinal plant are yet to be performed in this geographical region. This study aims at the analysis of *Mesuaferea* auct Linn. plant for the activity concentrations and transfer factors of the radionuclides ^{226}Ra, ^{210}Pb, ^{232}Th, ^{40}K and ^{137}Cs . The study also intends to estimate average annual committed effective dose due to consumption and the threshold annual consumption rate of this medicinal plant.

Table -1: Medicinal uses of *Mesuaferea*		
Sl.No.	Plant Part	Medicinal property
1	Bark	Tonic, Bechic, Sudorific, Astringent, Anaemia, Nausea, Throat diseases
2	Leaves	Antidote for snake bite, Scorpion sting, Nausea, Throat diseases

Materials and Methods:Coastal Karnataka is a region with variety of medicinal plants and hence the practice of the traditional Ayurvedic medicinal system is well accepted by the general public. Puttur is a small town in the South Kanara district of this region. Commercial crops like, Arecanut, Cashew, Pepper, Cocoa, vanilla; food crops like Rice, coconut, spices, and vegetables are cultivated along with naturally grown medicinal plants of this region.

The bark and leaves samples of the medicinal plant, *Mesuaferea* auct Linn., and soil sample from its rooting area were collected from a location (N 12°45'18" E75°11'16") with its gamma background radiation level of 120 $nSvh^{-1}$. The collected samples were processed using the standard methods given in EML procedure manual (Herbert L.V and Gail D.P., 1983) and analyzed for ^{226}Ra, ^{210}Pb, ^{232}Th, ^{40}K and ^{137}Cs activity concentrations, following the standard methods and procedures. All the above listed radionuclides have been estimated using gamma spectrometric method (Karunakara et al., 2003).The detectable level (BDL) 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).The spectrometer was calibrated using standards obtained from IAEA. The soil-to-plant transfer factor (T.F.) is calculated using the formula;

TF = Activity of radionuclide in plant ($Bqkg^{-1}$dry weight)/Activity of radionuclide in soil ($Bqkg^{-1}$dry weight) (Karunakara, 1997)

TheAverage Annual Committed Effective Dose (AACED) to an individual, due to consumption of the medicinal plants by the ingestion of naturally occurring radioactive materials (NORMs) was estimated using the equation (Lordford et al., 2013 and Njinga et al., 2015):

$E_{av}=C_r.\ DCF_i\ .A_i$ (1)

where, E_{av} is the average annual committed effective dose, C_r is the consumption rate of radionuclides, and DCF_i is the dose conversion factor for each radionuclide (2.8×10^{-7}, 6.9×10^{-7}, 2.3×10^{-7}, 6.2×10^{-9},and 1.3×10^{-8}Sv Bq^{-1} for ^{226}Ra, ^{210}Pb, ^{232}Th, ^{40}K, and ^{137}Csrespectively),and A_i is the activity concentration of each radionuclide.Using the same equation, the annual threshold consumption rate for a medicinal plant is obtained;

$Cr = \frac{5Eav}{\sum_{i=1}^{5}(DCFi\times Ai)}$ (2)

where, E_{av}=0.3mSv/y is the threshold average annual committed effective dose due to ingestion of NORMs in the medicinal plants,$A_i$is the activity concentration of radionuclide i, and DCF_i is the dose conversion factor for radionuclide i (UNSCEAR, 2000).

Results and discussion:

Table -2: Activity concentrations and transfer factors of radionuclides						
Radionuclide	Activity Concentration ($Bqkg^{-1}$)			TF		
	soil	bark	leaves	Soil to bark	Soil to leaves	bark to leaves
^{226} Ra	50.97±1.32	7.64±0.33	4.37±0.46	0.14	0.08	0.57
^{210}Pb	70.66±6.43	45.83±4.03	40.47±4.92	0.64	0.57	0.88
^{232}Th	84.08±2.67	10.26±0.52	BDL	0.12	BDL	BDL
^{40}K	86.14±6.59	432.03±3.15	2136.00±154.06	5.01	24.79	4.94
^{137}Cs	6.32±0.66	BDL	BDL	BDL	BDL	BDL

The activity concentrations of ^{226}Ra, ^{210}Pb, ^{232}Th, ^{40}K, and ^{137}Cs in bark and leaves samples of *Mesua ferea* plant and in the corresponding soil sample of the rooting area of this plant are presented in Table - 2.Column 2 of the Table-2,reports the activity concentrations of ^{226}Ra, ^{210}Pb, ^{232}Th, ^{40}K, and ^{137}Cs in the soil of the rooting area and they were found to be 50.97±1.32,70.66±6.43, 84.08±2.67, 86.14±6.59, and 6.32±0.66 $Bqkg^{-1}$respectively.Column 3 of the Table-2, presents the activity concentrations of the above said radionuclides in bark of *Mesua ferea* plant and were found to be7.64±0.33, 45.83±4.03,10.26±0.52,432.03±3.1 $Bqkg^{-1}$,and BDL respectively. The activity concentrations of ^{226}Ra, ^{210}Pb, ^{232}Th,^{40}K, and ^{137}Cs in leaves of the *Mesua ferea* plant were found to be 4.37±0.46, 40.47±4.92, BDL, 2136.00±154.06 $Bqkg^{-1}$,and BDL respectively, as presented in column 4.The concentrations of radionuclides in soil, leaves and bark are also presented in the form of histogram in Fig. 1.

The activity concentrations of ^{232}Th and ^{40}K in soil sample are in almost equal concentration (84.08±2.67 and 86.14±6.59$Bqkg^{-1}$).But it can be seen that the concentration of ^{232}Th in bark sample is about 10.26±0.52 $Bqkg^{-1,}$ whereas the activity concentration of ^{40}K is about 432.03±3.15 $Bqkg^{-1}$. In leaves, ^{232}Th is found to be BDL and ^{40}K was found to be 2136.00±154.06 $Bqkg^{-1}$. It is also found that the activity concentration of ^{40}K is very large compared to any other radionuclide in both bark and leaves sample. This may be because of the fact that the 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 higher concentration of ^{40}K in medicinal plant samples compared to soil sample may be due to the continuous accumulation of ^{40}K through root uptake over a period of time (ChethanRao, 2012).

In spite of its significant activity concentration in soil, ^{232}Th is found to have the lower value for its activity concentration in bark and leaves of the medicinal plant. Because of its low solubility and specific activity, ions of ^{232}Th may be bound tightly to the soil particles, so that they are immobile and may not be transported to the medicinal plants (Eisenbud, 1987).This may be the reason for lower activity concentration of ^{232}Th in bark and leaves.

The soil to bark, soil to leaves, and bark to leaves transfer factors (TF) of the above said radionuclides are presented in the columns 5, 6, and 7 respectively of Table-2 and also presented in the form of histogram in Fig. 2. It is observed in the study that the soil to plant transfer factors of ^{226} Ra are higher than that of ^{232}Th, in spite of the higher concentrations of ^{232}Th in soil samples. This is because, the radium dissolves more easily in water than thorium; consequently it is transported to the plant through absorption of water through root. Radium exhibits similar chemical properties as that of calcium and magnesium, which are essential elements for the growth and nutrition of plants. In place of Ca and Mg, plants may take up ^{226}Ra depending on its availability in soil (Somashekarappa, 1993).

The soil to plant transfer factors of ^{210}Pb are comparatively higher compared to other radionuclides except for that of ^{40}K. This may be because of the fact that in addition to root uptake, ^{210}Pb is also largely available in the atmosphere and deposit as a fall-out of ^{222}Rn daughters on aerial parts of medicinal plant in the form of wet and dry precipitate and subsequent absorption (Parfenov, 1974). The ^{137}Cs is found to be present in smaller quantity (6.32±0.66) in the soil sample. The availability of this artificially produced radionuclide in the soils across the continents as a fall-out radionuclide is mainly due to open atmospheric tests conducted by some countries prior to the ban of open atmospheric tests (Somashekarappa, 1993).

The average annual committed effective dose (AACED), due to ingestion of naturally occurring radionuclides (NORMs) in the medicinal plant *Mesua ferea* and annual threshold consumption rate of medicinal plant were estimated using equations 1 and 2.The AACED values due to consumption of medicinal plant at the consumption rate of 1kg/y (Njinga et al., 2015) were 0.0387±0.0032 mSv/y and 0.0423±0.0044 mSv/y respectively for the bark and leaves. It was found that the estimated AACED due to consumption of leaves of *Mesua ferea* plant as a medicine is more compared to that of bark of the same plant.This may be due to higher activity concentration of ^{40}K in leaves of this medicinal plant.But the AACED values presented in this study are far below the world average of 0.3 mSv/y (UNSCEAR, 2000). Thus the present study suggests that there is no radiological health risk in using these medicinal plants for treating the diseases.

The annual threshold consumption rate for the bark and leaves of this medicinal plant were found to be 7.75 kg/y and 7.09 kg/y respectively.

Conclusion: The present study proved the presence of natural radionuclides,^{226}Ra, ^{210}Pb, ^{232}Th, and ^{40}K,in bark and leaves samples of the medicinal plant, *Mesua ferea* auct Linn. The activity concentration of the radionuclide ^{40}K was maximum among the measured radionuclides in the medicinal plant, both in case of bark and leaves. The ^{40}K activity concentration was found be more in leaves compared to that of bark. Consequently the uptake of ^{40}K is maximum followed by ^{210}Pb in both bark and leaves of this plant.The average annual committed effective dose (AACED), due to ingestion of naturally occurring radionuclides (NORMs) due to consumption of bark and leaves of this medicinal plant is far below the world average (0.3 mSv/y).Thus the study shows that there is no radiation health hazard in using the bark and leaves of *Mesua ferea* for medicinal purpose. This study provides the first hand report of activities of natural radionuclides and acts as a baseline data for the radiological safety studyin this medicinal plant.

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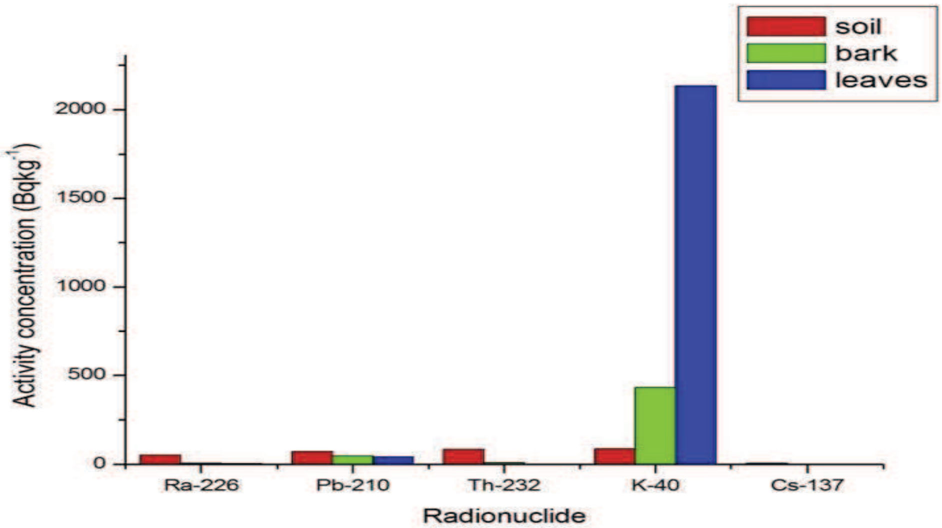

Fig 1: Activity concentration of radionuclides in soil, bark, and leaves.

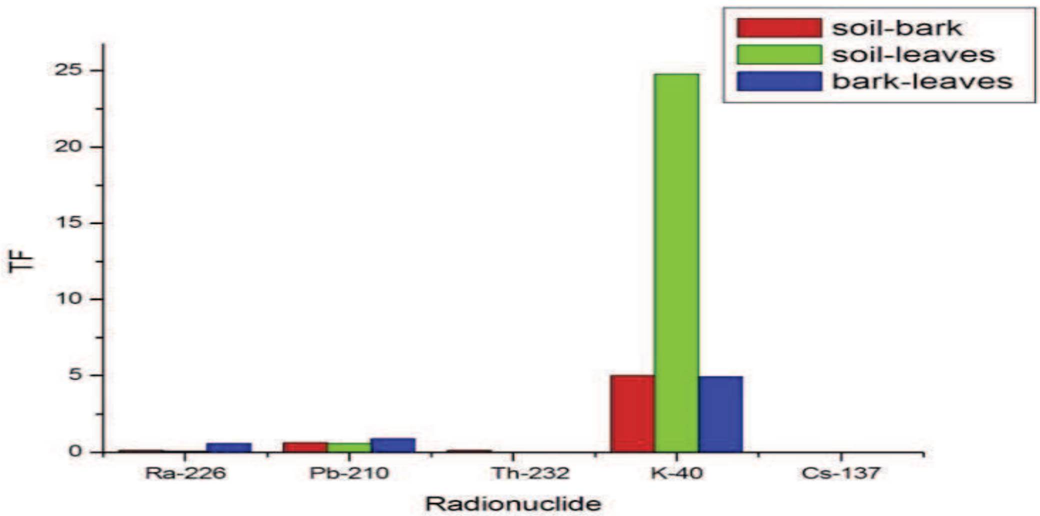

Fig 2: Transfer factors of radionuclides

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