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Estimation of radionuclides concentration and average annual committed effective dose due to ingestion for some selected medicinal plants of South India

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ARTICLE INFO

Article history:
Received 22 June 2015
Received in revised form
4 September 2015
Accepted 16 September 2015
Available online 1 October 2015

Keywords:
Medicinal plants
Curative property
Radionuclides
Therapeutic agents
Ayurvedic system

ABSTRACT

Eight medicinal plants and soil samples from the Malnad area of Karnataka in South India (N 13°29′35.4″; E 75°18′02.4″) were analysed for activity concentrations of natural and artificial radionuclides using HPGe gamma spectrometry. The average annual committed effective dose (AACED) due to the ingestion of radionuclides from medicinal plants were also estimated. The activity concentrations of ^{226}Ra, ^{210}Pb, ^{232}Th, and ^{40}K were found to vary in the range of 32.27–60.12 Bqkg^{-1}, 56.09–160.56 Bqkg^{-1}, 49.61–98.46 Bqkg^{-1}, and 241.57–712.85 Bqkg^{-1}, respectively, in the soil samples and 2.66–11.27 Bqkg^{-1}, BDL to 87.03 Bqkg^{-1}, 2.42–8.72 Bqkg^{-1}, and 93.79–6831.40 Bqkg^{-1}, respectively, in the medicinal plants corresponding to the soil samples. The activity concentration of artificially produced radionuclide ^{137}Cs was BDL to 12.34 Bqkg^{-1} in the soil and it was below detectable level (BDL) in all the plant samples. The soil to plant transfer factors (TF) varied from 0.07 to 0.27, BDL to 0.80, 0.04 to 0.13 and 0.17 to 23.80, respectively, for ^{226}Ra, ^{210}Pb, ^{232}Th, and ^{40}K. The AACED due to the ingestion of radionuclides from the medicinal plants varied from 0.0075 to 0.1067 mSvy^{-1}. The AACED values reported in this study are much below the world average value of 0.30 mSvy^{-1} for an individual. This indicates that there is no radiological health risk in using these plants for medicinal purposes. This study may also contribute data on local medicinal plants to formulate regulations related to radiological healthcare.

1. Introduction

The use of medicinal plants for treating diseases is probably the oldest existing method that humanity has used to cope with illnesses. Medicinal plants have been used therapeutically all around the world and is an important aspect of various traditional medicine systems. From Ayurveda to the Chinese traditional medicine, from Unani to Tibetan medicine, from Amazonian to African medicine, all systems,

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Peer review under responsibility of The Egyptian Society of Radiation Sciences and Applications.
http://dx.doi.org/10.1016/j.jrras.2015.09.005

although based on different theoretical and cultural models, integrate phytotherapy into their doctrine (WHO, 2007). Medicinal systems such as Ayurveda, Yoga, Unani, Siddha, and other traditional systems are in regular practice all over India, and more so in rural areas. All these systems use plants and different parts of the plants as the main ingredients of the medicine.

It is well-known that there are many contaminants and residues that may harm the consumers of herbal medicines, and naturally occurring radionuclides are one type of contaminants amongst them (WHO, 2007). In most places on earth, natural radioactivity varies only within relatively narrow limits, whereas in some other localities significant deviations have been observed. All these radionuclides present in the environment are taken up by the plants through the metabolic process and are present in varied concentrations in different parts of the plants (Golmakani, Moghaddam, & Hosseini, 2008; Harb, E-Kamel, E-Mageed, Abbady, & Rashed, 2014; Karunakara, 1997; Kannan, Rajan, Iyengar, & Ramesh, 2002; Lordford, Emmanuel, Cyril, & Alfred, 2013; Patra, Jaison, Baburajan, & Hegde, 2008).

Moreover, the plants absorb many elements present in the soil of their root area with or without the necessity of these elements. Sometimes, the uptake of some non-essential radioactive elements to the plants may occur along with chemically similar essential elements required for the plant metabolism (Manigandan & Chandrashekar, 2014). The transport of these radionuclides also depends on the chemical form of the nuclide, its distribution coefficient, the metabolic requirements of the plant, and physicochemical parameters of the soil such as pH, organic matter, moisture content, etc. (Eisenbud, 1987; IAEA, 2006; Lordford et al., 2013). The presences of radionuclides such as ^{226}Ra, ^{210}Po, ^{210}Pb, etc., in the soil are metabolically incorporated into the plants and ultimately find their way into the food chain. The presence of radionuclides in varied concentrations in different parts of the plants may be transferred to human beings, since their parts are used as ingredients in preparing the medicines. The estimation of risk to humans from medicinal plants through ingestion requires a quantitative understanding of the interrelated pathways by which the radionuclides are eventually ingested by humans (Eisenbud, 1987). Thus, it is important to study the uptake and activity distribution of radionuclides and the probable effective radiation dose to humans, by the use of medicinal plants.

2. Materials and methods

2.1. Sampling area

The Malnad region (N 13°29′35.4″; E 75°18′02.4″) of Karnataka is a part of the Western Ghats of South India. The eastern parts of Dakshina Kannada and Udupi districts, and parts of Belgaum, Uttara Kannada, Chikkamagalur, Shimoga, Hassan, and Kodagu districts of Karnataka state come under this region. Medicinal plant samples are collected from Chikkamagalur district of this region (Fig. 1). The entire region is agrarian and arecanut, coffee, pepper, tea, rice, ginger, turmeric, vanilla, cardamom, etc. are the important crops grown in this region. The population of this region use Ayurvedic and folklore medical systems extensively in which different parts of the plants are used as main ingredients.

2.2. Sampling

Eight medicinal plants used extensively for treating various diseases were identified for investigation under this study. Different parts of the plants used as ingredients in medicine preparation in this region were collected, following the standard methods given in EML procedure manual (Volchok & De Planque, 1983). Polythene bags washed with distilled water were used to store the plant samples, and then, taken to the laboratory. Soil samples were also collected from the rooting area of the plants. The details of the medicinal plants such as sample number, common and botanical names, curative properties, and parts of the plant used as ingredients in medicine are presented in Table 1.

2.3. Sample preparation

The medicinal plant samples were first air dried, and then, dried at 110 °C in an oven until a constant dry weight was obtained. The samples were charred over a low flame on a gas stove and ashed in a muffle furnace at 450 °C until a uniform white ash was obtained. The ash was stored in a 300 ml polythene container, sealed, and kept for one month to achieve secular equilibrium between ^{226}Ra and its daughters (Volchok & De Planque, 1983). Activity concentrations of ^{226}Ra, ^{210}Pb, ^{232}Th, ^{40}K, and ^{137}Cs were estimated using gamma spectrometric method (Karunakara et al., 2003). Soil samples were also processed following the standard methods given in EML procedure manual (Volchok & De Planque, 1983). Activity concentrations of ^{226}Ra, ^{210}Pb, ^{232}Th, ^{40}K, and ^{137}Cs in soil samples were estimated using gamma spectrometric method (Karunakara et al., 2003).

2.4. Sample analysis

The medicinal plant and soil samples were analysed for activity concentrations of ^{226}Ra, ^{210}Pb, ^{232}Th, ^{40}K, and ^{137}Cs using HPGe gamma spectrometer. A p-type closed end co-axial detector (Model BE3825, Canberra,USA) of dimensions 70 mm diameter and 25 mm length with an active area 3800 mm^2 having 38% relative efficiency was used in the present study. The energy resolution of the detector is 2.2 keV at 1.33 MeV with an operating voltage of 4000 V.The spectrum was analysed using a 16 K multi channel analyser connected to a computer using GENIE-2000 software. Quality assured standard materials procured from IAEA were used for the calibration of the detector. The reference materials used in the case of soil samples were RGU-238, RGTH-232, RGK-1, and Soil-6. IAEA-308 reference standard material was used for calibration and analysis of the ash samples. Same size containers were used for both, the reference standards and the samples under study. The ash samples were counted for 60,000 s and the soil samples for 30,000s. Longer counting time ensures least counting error. The activities of ^{210}Pb, ^{40}K, and ^{137}Cs were measured from their characteristic gamma lines of