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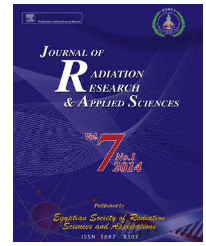

Evaluation of radionuclides in the terrestrial environment of Western Ghats

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ABSTRACT

The activity concentration of naturally occurring radionuclides in soil samples of an elevated radiation background area of Western Ghats were determined using gamma-ray spectrometry with the aim of evaluating the environmental radioactivity. The annual effective dose equivalent and the radiation hazard indices from the soil activity were estimated to reduce the harmful effects of gamma radiation to the population dwelling in the area. The activity concentrations of ^{232}Th and average outdoor terrestrial gamma dose rate were found to be higher than the world average, this may affect Western Ghats environment in general. Therefore, the radiological risks to the general population from ionizing radiation from the naturally occurring radionuclides in the soil are considered to be significant. However, other radiological hazard indices were found to be within permissible limits.

1. Introduction

Exposure to gamma radiation is mostly regarded as undesirable at every level, although no harmful effects are known to follow very low-levels of exposure. Recently, considerable attention has been given to low-level exposure arising from naturally occurring radionuclides, particularly ^{238}U, ^{232}Th, their decay products and ^{40}K. Natural radiation sources are very important and they deliver the highest radiation dose to which human beings are exposed to (Aborisade, Olomo, & Tchokossa, 2003; Marouf, Mohamad, & Taha, 1993). Natural radioactive concentration depends mainly on geological and geographical conditions and appears at different levels in soils from different geological regions (UNSCEAR, 2000) i.e. thorium and uranium may be redistributed during igneous, sedimentary and metamorphic cycles of geological evolution, which might have resulted in small concentrations of deposits under favorable geological processes. Available information indicates that the deposits of monazite on the coastal areas of Kerala and Tamil Nadu are formed due to the weathering of rocks in Western Ghats. Monazite sands consist of phosphate

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Fig. 1 – Distribution of Monazite sand along the Kerala coast.

minerals of elements such as cerium which occur as small brown crystals in the Kerala sands (these monazite sands are mined for both cerium and radioactive thorium oxide). The sands originate in the granites and gneisses of the Western Ghats and are transported to the coast by more than 47 streams that indent the Kerala coastline (Valithan, Kartha, Nair, Shivakumar, & Eapan, 1994) and it is shown in Fig. 1.

The study of the radioactive components in soil is a major link in understanding the behavior of radioactivity in the ecosystem, because these materials emit radiation by the disintegration of natural radionuclides and contribute to the total absorbed dose via ingestion, inhalation and external irradiation (Steinhausler et al., 1992). Also, soil acts as a source of continuous radiation exposure to humans and as a medium of migration for the transfer of radionuclides to the biological systems and causes radiological contamination in the environment. In addition to the natural sources, soil radioactivity is also affected by man–made activities. The sources of radioactivity in cultivated soils are mainly due to the extensive use of fertilizers, rich in phosphates, for agricultural purposes (Abbady, El-Arabi, Abbady, & Taha, 2008). The concentration of uranium and partial thorium are increased in environ due to these fertilizers. Usually fertilizers are considered as a technologically enhanced source of natural radiation (Abbady et al., 2008). Hence, soil radioactivity is usually important for the purpose of establishing baseline data for future assessment of radiation impact, radiation protection, and exploration.

2. Materials and methods

2.1. *Study area*

The soils analyzed were collected from elevations of between 2000 and 2400 m the Nilgiri Highlands, Tamil Nadu, South India, which are situated between 11° 00′ and 11° 30′ N and between 76° 00′ and 77° 30′ E. The Nilgiri massif is located at the junction between the Eastern and Western Ghats, and is bounded by abrupt slopes. The study area is shown in Fig. 2. The vegetation above 2000 m in the highlands is a mosaic of high-elevation evergreen forests, called ‘shola’ locally, and grasslands with different compositions of flora, including C4 grasses (Rajagopalan, Sukumar, Ramesh, & Pant, 1997; Sukumar, Suresh, & Ramesh, 1995).

2.2. *Sample collection*

The study area was divided into a 4-km grid and soil samples were collected from 25 sampling points in the natural, uncultivated, and grass-covered level areas within the grid, conforming to International Atomic Energy Agency recommendations (IAEA, 1989). The 25 sampling points followed a zig-zag pattern. Five 20-cm-deep samples were collected at equal distances along a 1-m circle around the center of each sampling point. This sampling method was used to improve the representativeness of the samples. The position and elevation of each sampling point was determined using a global positioning system.

2.3. *Sample processing*

The soil samples were transported to the laboratory and plant roots and other unwanted materials were removed. The samples were then dried in an oven at 105 °C for 12–24 h, ground, and passed through a 2-mm sieve. About 400 g of dry sample was weighed into a plastic container, which was capped and sealed. The container was sealed to ensure that none of the daughter products of uranium and thorium that were produced, particularly radon and thoron, could escape. The prepared samples were stored for one month before counting to ensure that equilibrium had been established between radium and its short-lived daughters. Detailed gamma-ray spectrometry analysis was performed on the soil samples.

2.4. *Activity determination*

The samples were analyzed using a NaI(Tl) spectrometer coupled with TNIPCAII Ortec model 8K multi-channel analyzer. The ^{232}Th-series, ^{238}U-series, and ^{40}K activities were estimated, as were the amounts of these radionuclides that would enter the air from the soil. A 3 inch × 3 inch NaI(Tl) detector was used, with adequate lead shielding, which