Journal of Environmental Radioactivity 99 (2008) 1665–1670

Contents lists available at ScienceDirect

Journal of Environmental Radioactivity

journal homepage: www.elsevier.com/locate/jenvrad

Spatial distribution of natural radioactivity levels in topsoil around the high-uranium mineralization zone of Kylleng-Pyndensohiong (Mawthabah) areas, West Khasi Hills District, Meghalaya, India

S.A. War [a,*], P. Nongkynrih [a], D.T. Khathing [a], P.S. Iongwai [b], S.K. Jha [c]

[a] Department of Physics, North Eastern Hill University, Shillong 793 022, Meghalaya, India
[b] Department of Zoology, North Eastern Hill University, Shillong 793 022, Meghalaya, India
[c] Environmental Assessment Division, BARC, Mumbai 400 085, Maharashtra, India

ARTICLE INFO

Article history:
Received 6 October 2007
Received in revised form 12 April 2008
Accepted 23 April 2008
Available online 4 June 2008

Keywords:
Natural radionuclides
Gamma-spectrometry
Uranium
Kylleng-Pyndensohiong (Mawthabah)
India

ABSTRACT

A study of background radiation and the distribution of radionuclides in the environment of the proposed uranium mining sites of Kylleng-Pyndensohiong (Mawthabah) areas, West Khasi Hills District, Meghalaya, India, has been carried out with the objective of establishing a baseline radiation level of the region. Topsoil samples collected from the region are analysed for radioactivity measurements of primordial radionuclides by gamma-spectrometry technique. Direct dose measurement using a survey meter was also carried out simultaneously. Measurement carried out in the region shows that the activity concentration of ^{238}U and ^{232}Th in soil samples is found to be highest in Kylleng with respective median values of 335.3 Bq kg^{-1} and 283.9 Bq kg^{-1} followed by Syngkai with activity concentration of 285.3 Bq kg^{-1} and 257.4 Bq kg^{-1} for ^{238}U and ^{232}Th, respectively. The distribution of ^{40}K concentration in the study area is found to be in the range of 173.1–359.0 Bq kg^{-1} which is below the global and Indian average values of 420 Bq kg^{-1} and 394 Bq kg^{-1}, respectively. The contribution of the primordial radionuclides to the total dose of the study area is found to be very high with a range of 136.8–334.5 nGy h^{-1} in comparison to the global as well as Indian average values.

1. Introduction

Ever since his appearance on earth, man is being exposed to radiation of natural origin at the earth's surface consisting of two components namely cosmic rays and radiation from the radioactive nuclide's in the earth's crust (Obed et al., 2005; Mohanty et al., 2004; UNSCEAR, 2000). The latter component, the terrestrial radiation, mainly originates from the so-called primordial radioactive nuclides that were made in the early stage of the formation of the solar system (Al-Jundi, 2002; Puranik, 2004). These radionuclides belong to the ^{238}U and ^{232}Th series as well as the radioisotopes of potassium ^{40}K and are the major contributors of outdoor terrestrial natural radiation (Puranik, 2004; Sadasivan et al., 2003; Shukla et al., 2001; UNSCEAR, 1993). While absorbed dose rate in air from cosmic radiation outdoors at sea level is about 30 nGy h^{-1} (UNSCEAR, 2000), the specific levels due to terrestrial background radiation are related to the types of rock from which the soils originate. Therefore, the natural environmental radiation mainly depends on geological and geographical conditions (El-Shershaby, 2002; Flourou and Kritidis, 1992; NCRP, 1975; Tzortzis et al., 2003).

High levels of background radiation are found in few places in the world. This is normally because of the occurrence of high soil surface concentrations of one or more of the natural radionuclides like uranium, thorium or potassium (Chougaonkar et al., 2004). In India, large amounts of thorium bearing monazite sands are found in Kerala and Orissa sea beaches (Eisenbud, 1977; Krishan et al., 2001; Mishra, 1993; Paul et al., 1988; Shukla et al., 2001; Sunta, 1993) while uranium deposits are found in Singbhum district in Jharkhand; Lambapur region in Andhra Pradesh and the Domiasiat (now Kylleng-Pyndensohiong, Mawthabah) areas in Meghalaya (Shaikh et al., 2004; Shukla et al., 2004).

Investigations on terrestrial natural radiation have received particular attention worldwide and led to extensive surveys in many countries. They mainly serve as baseline data of natural radioactivity such that man-made possible contaminations can be detected and quantitatively determined. They can further be used to assess public dose rates and to perform epidemiological studies (Al-Jundi, 2002; Tzortzis et al., 2003).

In Meghalaya, Kylleng-Pyndensohiong, Mawthabah (formerly known as Domiasiat) areas in West Khasi Hills District, about

* Corresponding author.
E-mail address: aaron2416@yahoo.com (S.A. War).

0265-931X/$ – see front matter © 2008 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jenvrad.2008.04.014

130 km south-west of Shillong, has been identified as an area having large and rich deposits of uranium. The uranium containing host rock in this region is of Arkose's (feldspar rich sandstone) type belonging to the Upper Cretaceous age group. The main uranium ores are pitchblende and coffinite of average grade around 0.10% U_3O_8. However, actual extraction on a commercial scale is yet to be undertaken (Chougaonkar et al., 2004; Gupta, 1997; Hoda, 2004; War and Nongkynrih, 2004). This paper aims to provide the radioactivity levels of ^{40}K, ^{238}U and ^{232}Th in soils and the associated external gamma dose rate estimates for the aforementioned uranium deposit areas.

2. Materials and methods

2.1. Sampling and sample preparation

Surface soil samples (0–10 cm depth) were collected from nine locations in and around the proposed uranium deposit areas. The geographical locations including latitudes and longitudes of the sampling sites are given in Fig. 1 and Table 2. The sampling was done from the available open areas which were least disturbed. For sampling, a method of the US-EML was adopted (USDOE, 1990). The area under survey was divided into a 100 m × 100 m grid and soil samples are collected from every 100 m × 100 m area. At every collection point, the area of 1 m × 1 m was marked and soil samples up to a depth of 10 cm are collected. Ten number of topsoil samples were collected from each location for carrying out the analysis of the activity concentrations of the primordial radionuclides. After collection, stones and grass are removed and the samples are homogenized. They are then air dried to remove moisture. About 350 g of soil samples were stored in an air-tight cylindrical plastic container so that secular equilibrium is attained between ^{226}Ra and its daughter products as well as between ^{228}Th and its daughter products. The containers were filled full for uniform distribution of ^{220}Rn and ^{222}Rn daughter products in the samples and to avoid any accumulation on the top.

2.2. Radioactivity measurement

^{40}K, ^{238}U and ^{232}Th in soil samples were measured by using a high resolution gamma-ray spectrometer consisting of a HPGe detector of 30% relative efficiency housed in a 7.5 cm thick lead shield, PC coupled 8K MCA card and associated electronics.

Energy calibration and efficiency evaluation of the gamma-spectrometer were done by using standards RGK-1, RGU-1 and RGTh-1 obtained from the IAEA in the appropriate matrix. The procedure for preparing secondary standards was described elsewhere (Sadasivan, 1989). The standards were packed in similar plastic containers, which were used for soil samples storage and counted after allowing time for attaining secular equilibrium.

Samples were counted for 60,000 s. ^{40}K in the samples was evaluated from 1460.8 keV peak. In ^{232}Th series, ^{228}Th was estimated from 238.6 keV (^{212}Pb), 583.14 keV and 2614.47 keV (^{208}Tl) energies and ^{228}Ac was measured through 911.1 keV. Also to study if any disequilibrium exists in ^{238}U series and ^{232}Th series, ^{238}U was measured from 1001.1 keV (^{234m}Pa) and ^{226}Ra was estimated from 186.2 keV (^{226}Ra), 609.3 keV and 1764.6 keV (^{214}Bi) and ^{214}Pb was measured through 351.99 keV. The well known interference between the gamma line of 186.2 keV of ^{226}Ra and 185.7 keV emitted by ^{235}U is inevitable especially in the presence of a high-uranium concentration (Al-Jundi, 2002; Caret, 1990). Therefore, the above-mentioned line was not used for the determination of ^{238}U. Measurements generally showed that Th and U series radionuclides were in radioactive equilibrium in the soil samples. The activity reported corresponds to the dry weight of about 350 g of the sample. The minimum detection limits (MDL) were estimated for radioactivity counting instruments using the statistical laws and the background count rate of the instruments for specific energy (Rangarajan, 1989). Table 1 gives the minimum detection limits for ^{40}K, ^{238}U and ^{232}Th for 350 g sample size and 60,000 s counting time.

In situ ambient radiation levels or external gamma radiation levels in air at each site were also measured using a Micro-R-Survey Meter (TYPE: UR 705, Nucleonix) whose minimum traceable limit is 8.8 nGy h^{-1}. The survey meter was kept at a height of 1 m above the ground while measuring the dose rate.

3. Results and discussions

3.1. Natural radionuclides in topsoil samples

Table 2 gives the range and the mean activity concentrations of ^{40}K, ^{238}U and ^{232}Th of the topsoil samples from the nine sampling locations in and around the uranium deposit areas. Of the nine locations investigated in this study, Kylleng and Syngkai appear to have the highest average concentrations of ^{238}U followed by Mawthabah and Nongbah Jynrin (Fig. 2). The ^{238}U concentration median values in these four locations are found out to be 335.3 Bq kg^{-1}, 285.3 Bq kg^{-1}, 192.1 Bq kg^{-1} and 173.3 Bq kg^{-1}, respectively. This is expected, since these locations lies within the Kylleng (Killung) block where majority of surface samples in Phot Killung or Kylleng have U_3O_8/eU_3O_8 factor varying from 0.67 to 0.94 indicating surface leaching environment but a few rich samples associated with carbonaceous matter have a factor of 1.0, even at

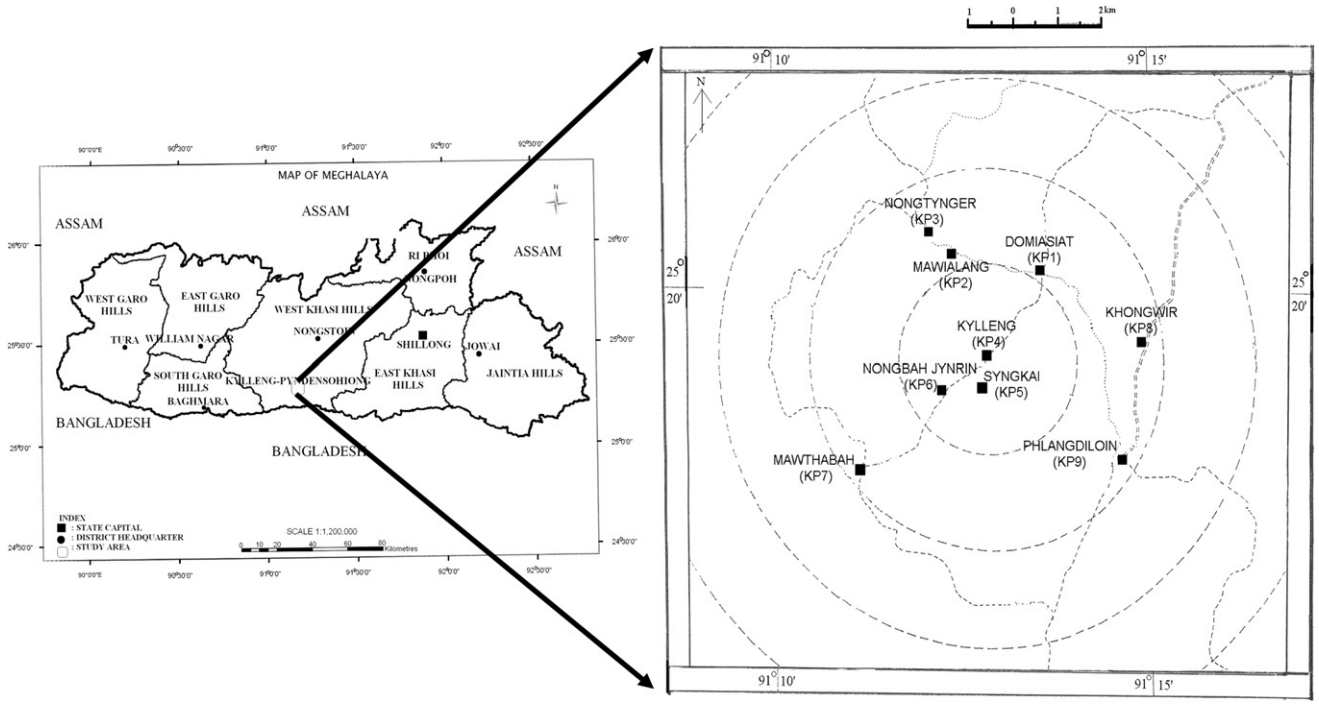

Fig. 1. The nine sampling locations in and around the uranium deposit areas.