Journal of Geochemical Exploration 142 (2014) 11–15

Contents lists available at ScienceDirect

Journal of Geochemical Exploration

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

Distribution of natural radioactivity in soil samples and radiological hazards in building material of Una, Himachal Pradesh

Pankaj Bala [a], Rohit Mehra [a,1,*], R.C. Ramola [b]

[a] Department of Physics, Dr. B.R.Ambedkar National Institute of Technology, Jalandhar, India
[b] Department of Physics, H. N. B. Garhwal University, Badshahi Thaul Campus, Tehri Garhwal, India

ARTICLE INFO

Article history:
Received 17 September 2013
Accepted 15 February 2014
Available online 22 February 2014

Keywords:
Natural radioactivity
Health hazards
Building material
Annual effective dose
Gamma ray spectrometry

ABSTRACT

In the present study, the concentrations of ^{226}Ra, ^{232}Th and ^{40}K are measured in building material and soil samples collected from different locations of Una, Himachal Pradesh, India. The collected soil samples and building materials are analysed using NaI(Tl) gamma ray spectrometry. The activity concentration of the naturally occurring radionuclides ^{226}Ra, ^{232}Th and ^{40}K in the soil samples varies from 36.4 to 51.9, 9.3 to 26.1 and 1361.0 to 1732.4 Bqkg^{-1}, respectively but in building material it varies from 27.8 to 236.0, BDL to 146.1 and 1059.6 to 1582.9 Bqkg^{-1}, respectively. The radium equivalent activity, absorbed dose rate, annual effective dose and hazard index are also calculated for the assessment of radiological risk. The concentration of radionuclides depends upon the rock formation and chemical properties within the earth. The average radium equivalent activity from the soil samples and building material is 177.6 and 201.1 Bqkg^{-1}. The concentration of ^{226}Ra, ^{232}Th and ^{40}K in the collected samples is higher than the world average concentrations of 35, 30 and 400 Bqkg^{-1}, respectively. This study is important to generate a baseline data for radiological mapping of the study area in the future.

1. Introduction

All building materials contain various amounts of natural radioactive nuclides. Materials derived from rock and soil contain mainly natural radionuclides i.e. uranium (^{238}U), thorium (^{232}Th) and potassium (^{40}K). In the uranium series, the decay chain segment starting from radium (^{226}Ra) is radiologically the most important and, therefore, reference is often made to radium instead of uranium. The world-wide average concentrations of radium, thorium, and potassium in the earth's crust are 35, 30 and 400 Bqkg^{-1}, respectively. To evaluate the radiation hazards, it is very important to estimate the natural radioactivity level in soils. The natural radioactivity of soil samples is usually determined from the ^{226}Ra, ^{232}Th and ^{40}K contents (OECD, 79). Even though these radionuclides are widely distributed, their concentrations have been found to depend on the local geological conditions and as such they vary from place to place (Tennisseen, 1994). Due to the health risks associated with the exposure to indoor radiation, many governmental and international bodies such as the International Commission on Radiological Protection (ICRP) and the World Health Organization (WHO) have adopted strong measures to minimize such exposures. Currently, a worldwide effort is underway to measure the activity concentrations in building materials (Tufail et al., 1992; UNSCEAR, 1988). A range of radioanalytical methods can be used for determination of activity concentrations in naturally occurring materials. Gamma-ray spectrometers are widely used for this purpose. These are typically based on either germanium semiconductor or NaI(Tl) scintillator detectors. Even though germanium-based detectors have higher resolution, NaI(Tl) detectors offer higher detection efficiency and lower price and are relatively easy to use. They are the preferred choice in cases where the photo-peaks of concern are well separated (IAEA, 1992). Some radioactivity studies have been previously carried out in soil and sediment samples in some parts of the world (Beaza et al., 1992; Kannan et al., 2002; Kirchner et al., 2002; Krishnamoorthy et al., 2013; Mehra et al., 2007; Noordin, 1999; Patra et al., 2006; Selvasekarapandian et al., 2000; Senthilkumar et al., 2010). The aim of the present work is to study ^{226}Ra, ^{232}Th and ^{40}K radioactivity concentration in soil and building material collected from Una district of Himachal Pradesh.

2. Experimental details

2.1. Study area

Una district lies within North latitude 31°17′52″ and 31°52′0″ and East longitude 75°58′2″ and 76°28′25″. Una is in the south-western part of Himachal Pradesh. The map of the Una district with study locations is shown in Fig. 1. Una district covers an area of 1549 sq.kms in Himalayan foothill zone bounded by plains of Punjab in the west and Solah Singhi Dhar in the east. The Una District has unique identity by having both plain areas and hilly areas. Alluvial fans, river terraces

* Corresponding author.
E-mail address: mehrar@nitj.ac.in (R. Mehra).
[1] Tel.: +91 9888534590; fax: +91 0181 2690320.

http://dx.doi.org/10.1016/j.gexplo.2014.02.010
0375-6742/

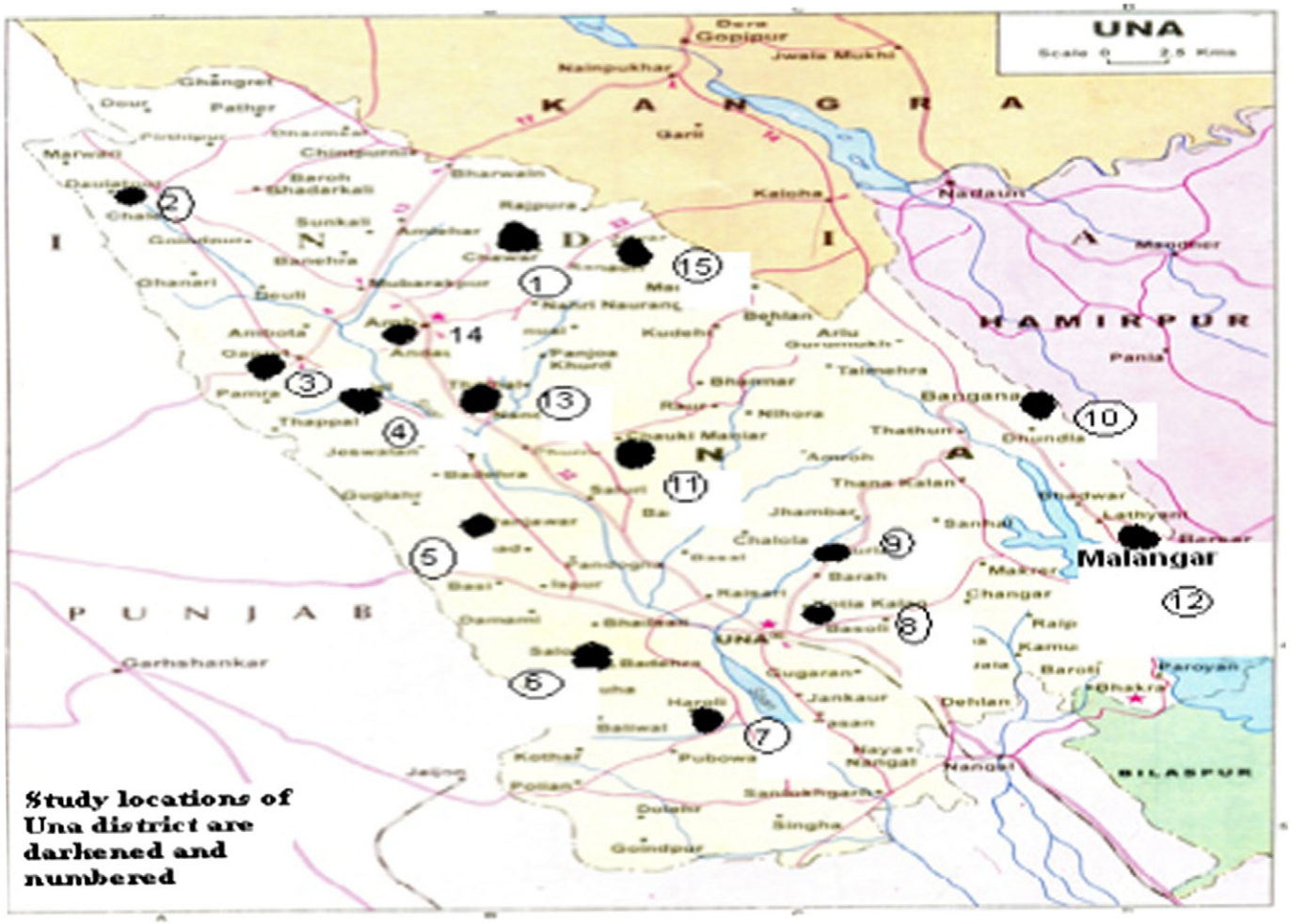

Fig. 1. Map of the study location (Una district of Himachal Pradesh).

and gravel beds of recent age and the sandstone, clay stone and conglomerates belonging to Shivalik group are the main formations in this area. Alluvium occupies the vast stretch of the plain. They contain sand, silt and clay in varying proportions.

2.2. Sample collection and preparation

In the present study, top surface soil samples up to a depth of 10 cm are collected from different locations of the Una region of Himachal Pradesh, India. Also twenty two samples of building materials (six types of marbles, six types of granite and ten types of sandstone) are collected from different manufacturers in the Una district. After collection, organic material, pebbles, roots and vegetation are separated from the soil samples, and all samples are crushed into a fine powder. Then, the samples are dried in an electric furnace at about 110 °C and sieved through a 150 μm sieve. Each dried sample of 250 g is packed in a Marinelli beaker of 250 ml capacity to allow uniform distribution of ^{220}Rn and ^{222}Rn decay products. These sample containers are stored for a period of one month before gamma spectrometric analysis, so as to allow the establishment of secular equilibrium between ^{226}Ra, ^{232}Th and their decay products (Shanbhag et al., 2005).

2.3. Gamma ray spectrometry

The radionuclides, ^{226}Ra, ^{232}Th and ^{40}K, are measured in soil samples and building materials using a gamma ray spectrometer. The prepared samples are placed in a shielded gamma ray spectrometry unit for a counting time of 3 h. The measurement of natural radionuclides is carried out using a NaI(Tl) gamma radiation detector of size 63 mm × 63 mm with a multichannel analyzer. The activity of ^{40}K is evaluated from the 1460 keV photo peak; the activity of ^{226}Ra from the 1764 keV gamma line of ^{214}Bi; and that of ^{232}Th from the 2610 keV gamma line of ^{208}Tl. This spectral analysis is performed with the aid of computer software SPTR-ATC (AT-1315). The peak energies of the gamma spectra are measured in reference to the 661 keV photo peak of ^{137}Cs. The activity concentration of the samples is calculated from the intensity of each line in the spectrum, taking into account the mass, the geometry of the samples, the counting time and the efficiency of the detector. The lower detection limits of the radionuclides ^{226}Ra, ^{232}Th and ^{40}K are 3 Bqkg^{-1}, 3 Bqkg^{-1}and 30 Bqkg^{-1} respectively.

2.4. Evaluation of radium equivalent activity

The distribution of natural radioactivity in the soil is not uniform. Uniformity with respect to exposure to radiation has been defined in terms of radium equivalent activity (Ra_{eq}) in Bqkg^{-1} to compare the specific activity of materials containing different amounts of ^{226}Ra, ^{232}Th and ^{40}K. The criterion for this model considers the external hazard due to gamma rays correspond to a maximum Ra_{eq} of 370 Bqkg^{-1} for the building material. This Ra_{eq} is calculated through the following relation (Yu et al., 1992):

$$Ra_{eq} = C_{Ra} + 1.43C_{Th} + 0.077C_K$$

where C_{Ra}, C_{Th} and C_K are the activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K in Bqkg^{-1}, respectively. When defining Ra_{eq}, it was assumed that