Radiation Physics and Chemistry 80 (2011) 710–715

Contents lists available at ScienceDirect

Radiation Physics and Chemistry

journal homepage: www.elsevier.com/locate/radphyschem?

Assessment of natural and anthropogenic radioactivity levels in rocks and soils in the environments of Juban town in Yemen

A.I. Abd El-mageed [a,*], A.H. El-Kamel [a], A. Abbady [b], S. Harb [b], A.M.M. Youssef [b], I.I. Saleh [c]

[a] Department of Physics, Faculty of science, Assiut University, Egypt
[b] Department of Physics, Faculty of Science, South Valley University, Egypt
[c] Department of Physics, Faculty of Education—Toor Albaha, University of Aden, Yemen

ARTICLE INFO

Article history:
Received 23 July 2010
Accepted 18 February 2011
Available online 24 February 2011

Keywords:
Radioactivity
Rock
Soil
Radiological effects
Radium equivalent
External hazard index

ABSTRACT

The natural radioactivities of ^{40}K, ^{226}Ra, and ^{232}Th and the fallout of ^{137}Cs in rock and soil samples collected around Juban town in Yemen (south west of Asia) were measured. Concentrations of radionuclides in samples were determined by gamma-ray spectrometer using HPGe detector with specially designed shield. The average radioactivity concentrations of ^{226}Ra, ^{232}Th, and ^{40}K were determined expressed in Bq/kg. The results show that these radionuclides were present in concentrations of (53.6 ± 4, 127 ± 6.7, and 1742.8 ± 62 Bq/kg), (55 ± 4, 121 ± 6.6, and 2341 ± 78 Bq/kg), (212.8 ± 8.7, 109 ± 5.5, and 32.4 ± 4.7 Bq/kg), and (32.1 ± 3, 22.3 ± 2.9 and 190.9 ± 15 Bq/kg) for granite, gneiss, siltstone, and sandstone rocks, respectively. For soil the corresponding values were 44.4 ± 4.5, 58.2 ± 5.1, and 822.7 ± 31 Bq/kg. Low deposits of ^{137}Cs were noted in investigation area, where the activity concentrations ranged from 0.1 ± 0.1 to 23.2 ± 1.2 Bq/kg. Also the radiological hazard of the natural radionuclides content, radium equivalent activity, total dose rates, external hazard index, and gamma activity concentration index of the (rocks/soils) samples in the area under consideration were calculated. The data were discussed and compared with those given in the literature.

1. Introduction

Studies and survey of natural environmental radiation are of great importance and interest in health physics not only for many practical reasons but also for more fundamental scientific reasons. The progressive development of the nuclear industry and other contaminating technologies necessary for widespread and ever-increasing use of radiation and radioactive isotopes makes it absolutely necessary to evaluate the background of natural radiation in order to detect humanly manufactured contamination to protect the population and the environment. At the same time, since natural radiation is the main source of human exposure, studies of the dose from this source and its effects on health improve the understanding of radiation damage and, therefore, are of great value as a reference when standards and regulatory control actions on radiation protection are established.

Natural radioactivity arises mainly from the primordial radionuclides, such as ^{40}K, and the radionuclides from ^{238}U and ^{232}Th series and their decay products, which are present at trace levels in all ground formations (Tzortzis et al., 2004). The knowledge of concentrations and distributions of the radionuclides in these materials of the radionuclides is of interest since it provides useful information in the monitoring of environmental radioactivity. Gamma radiation emitted from naturally occuring radioisotopes, also called terrestrial background radiation, represents the main external source of irradiation of the human body. Natural environmental radioactivity and the associated external exposure due to gamma radiation depend primarily on the geological and geographical conditions, and appear at different levels in the soils of each region in the world (Abbady et al., 2006; El-Arabi et al., 2000).

Measurements of the levels of natural background level of the radioactivity from ^{226}Ra and ^{232}Th (and their decay progeny), as well as the primordial radionuclide ^{40}K are the main objective of the current study. In addition, measurements of activity arising from decays of the artificially created fission product ^{137}Cs have been made in parallel.

2. Experimental

2.1. Geological setting

The Republic of Yemen is located in the southern sector of the Arabian Peninsula (Fig. 1). Juban town area (~55 km^2) is located some 220 km Southeast of Sana'a and located between lat. 13°57′ and 14°04′N and long. 44°47′ and 44°57′E (Fig. 1), the area around Juban town constitutes three main lithologic rock units: gneissic granites and granitoids of Precambrian age, cretaceous sandstones

* Corresponding author. Tel.: +20 100493535; fax: +20 882342708.
E-mail address: mageed39@yahoo.com (A.I. Abd El-mageed).

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doi:10.1016/j.radphyschem.2011.02.025

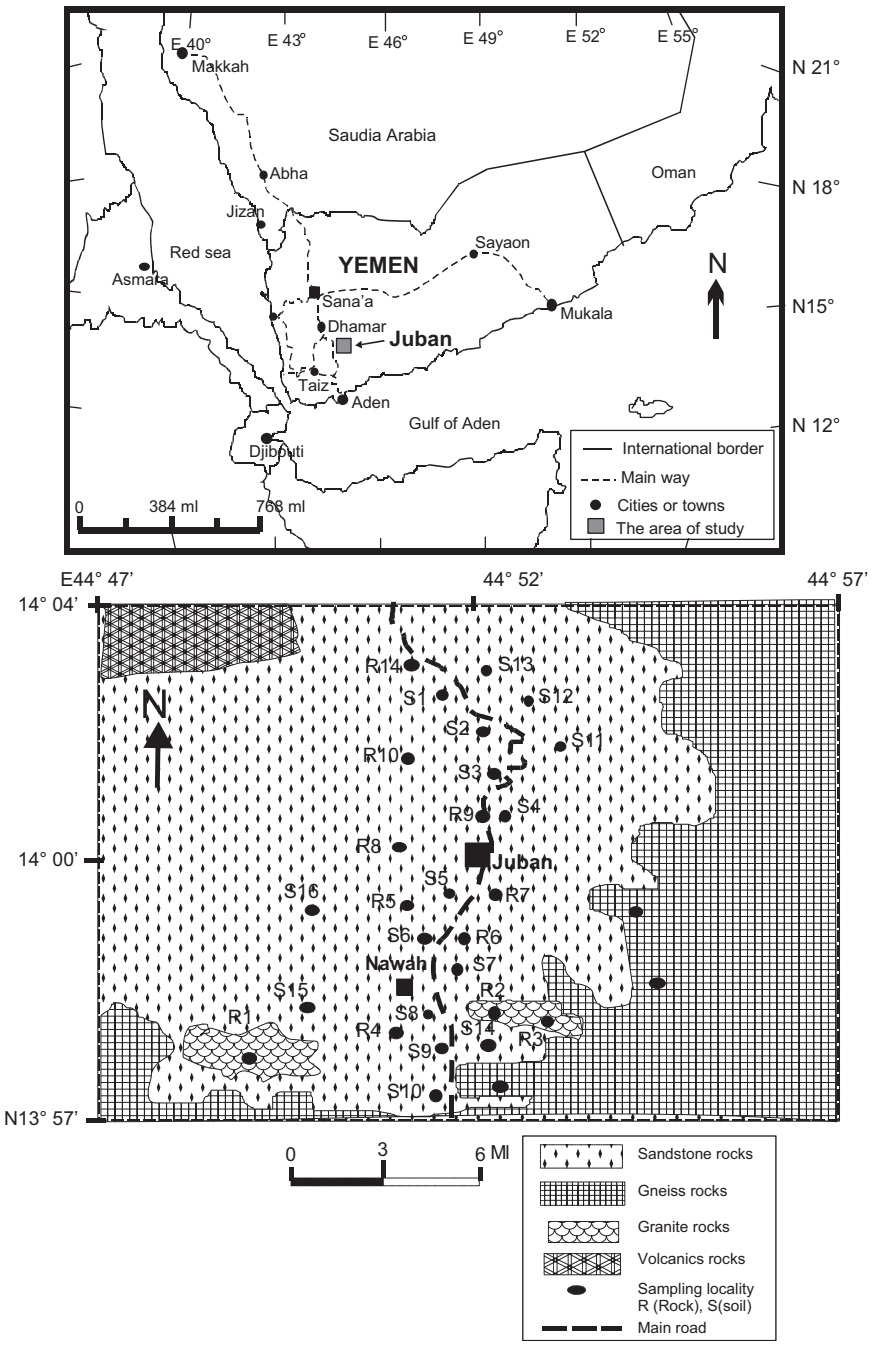

Fig 1. Sampling location.

and tertiary volcanics (Al-Khirbash et al., 2001; Heikal, 1987). Tertiary volcano comprises basalt flows, ignimbrites and tuffaceous rocks. Field data reveal unconformable and fault contacts between cretaceous sandstone and Precambrian gneissic granite. Cretaceous sandstone rested as an unconformable contact on the Precambrian granite–gneissic granite. The faults occurring in cretaceous sandstone may be reactivated basement structures. Precambrian basement includes granites and gneissic granite giving rise to discordant intrusive sharp contact (Heikal et al., 2007).

2.2. Sampling and sample preparation

A total of 14 rocks and 16 surface soil samples have been collected randomly from the studied area. Rock sample was crushed to small pieces and ground to powder. Soil samples were collected with the only constraint that no sampling site should be taken close to a field boundary, a road, a tree, or other obstruction. Surface soils were then taken from different places within the marked and cleared area from the ground surface up to 2 cm, and mixed together thoroughly in order to obtain a representative sample of that area. Each sample (rock/soil) was dried in an oven at 105 °C and sieved through a 100 mesh, which is the optimum size enriched in heavy mineral (Walley El-Dine et al., 2001). The samples were packed in polyethylene containers of dimension 75 mm in diameter and 90 mm height. The samples were weighed and stored for a minimum period of one month to allow daughter products to come into radioactive secular equilibrium with their parents ^{226}Ra and ^{232}Th and then were counted for 480–720 min depending on the concentration of the radionuclides.