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Method Article

Assessment of radiological parameters and metal contents in soil and stone samples from Harrat Al Madinah, Saudi Arabia

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A B S T R A C T

The current work deals with measurement and distribution of natural radionuclides for twelve (12) soil and fifteen (15) stone samples collected from Harrats Al Madinah in western region of Saudi Arabia. Two methods were used in this investigation gamma-ray spectrometer (GRS) and X-ray fluorescence (XRF).The activity concentrations of radionuclides (^{226}Ra, ^{232}Th and ^{40}K) were measured using γ-ray spectrometer NaI(Tl) model (A320) made in the U.S.A. The average values of the concentrations of ^{226}Ra, ^{232}Th and ^{40}K were 37.5 ± 0.1, 28.0 ± 0.5 and 300.6 ± 1.7 Bq/kg respectively. The obtained results show that the mean radium equivalent activity, annual effective dose, external and internal hazard indices and radiation level index were 100.67 BqKg^{-1}, 55.63μSv, 0.27, 0.37 and 0.73 respectively. The results were compared with the recommended limits in the literature from other locations and with the global allowable limits recommended by International Commission on Radiological Protection and United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). The obtained results are concordant with the magnitude of safe criteria and exposure risks which were recommended in public papers. The current study is considered as the first baseline data for the natural radioactivity and metal contents measured by X-ray fluorescence method in the Harrat Al Madinah city.

A R T I C L E I N F O

Keywords: Natural radioactivity, Radiation hazards, Annual effective dose rate
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Method details

Natural background radiation are the main sources of outdoor terrestrial gamma dose as humans are continuously exposed to ionizing radiation from natural radionuclides like ^{226}Ra, ^{232}Th and ^{40}K from the soil. [1] A person is exposed approximately eighty percent of the total radiation dose in a year [2,3]. Soil is one of the most common sources of natural radionuclides. The activity concentrations of radioelements and chemical elements depend on the geological setting and geochemical properties of each region caused by surrounding environment. Thus, the information of the contents of radionuclides is necessary to estimate the radiation risk on environment [4–9].

Al Madinah El Monawara is one of the most important cities in Saudi Arabia where people visit every year from all over the world. There is a lack of data about the contents of natural radioactivity on the studied area. This research is considered the first study in that region. However, a continuous monitoring and assessment of radionuclides fingerprints and contamination is advocate.

The current study focuses on radiometric and chemical analysis of soil and stone samples collected from Al Madinah city in Saudi Arabia using X-ray fluorescence (XRF) and NaI (Tl) scintillation detector.

Geological setting

The study area lies between longitudes 34° to 46° and latitudes 17° to 32° in the western region of Saudi Arabia Fig. 1. The most important characteristic of Harrat Al Madinah from the geological point of view is the existence of volcanic eruptions. The soil and stones found in the area are dark basaltic rocks formed by the eruption of lava from the ground to the surface [10].

Experimental technique

Samples preparation

About 0.5–1.0 kg of twelve (12) soil and fifteen (15) stone samples were collected between 0 and 10 cm of land surface from different locations in Al Madinah, KSA. There are many steps to samples preparation before radiometric and chemical analysis as follows:

(1) Soil and stone samples were dried at 105 °C to remove moisture completely, and then split by quartering to ensure the distribution of the elemental contents.
(2) Crushed and sieved through a 200 mesh to become homogenous.
(3) For radiometric analysis, each sample was weighed and placed in a 350 cm^3 beaker, and then sealed tightly for four (4) weeks to allow for secular equilibrium to ensure that radon gas is confined within the volume in the sample [11].
(4) For X-ray fluorescence (XRF), about 8 g from powder sample and 1.6 g of wax were taken and pressed under suitable pressure to prepare discs for elemental measurements [12–14].

Instrumentation and calibration

A gamma ray scintillation spectrometry NaI(Tl) detector model A320 and SN A3200829 was used to determine activity concentrations of radionuclides. The hermetically sealed assembly is coupled to a personal computer-multichannel analyzer (Canberra AccuSpec) model MCA2500R and serial 25,066. The detector was shielded to reduce background radiation using lead shield (100 mm thick) and copper shield (0.3 mm thick). Quantum Gold version 4.04.4 PGT (Princeton Gamma-Tech) was used to analyze gamma ray spectrum [4]. An empty beaker was used in the same condition of samples measuring to estimate the background radiation around the work environment. The accumulated spectrum of background was subtracted from specified photo-peak energy of each sample to get accurate measured activity.