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Radiation properties for red soil in Qassim province, Saudi Arabia

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ABSTRACT

It is important to measure the radionuclide concentrations in red soil to determine the health effect and to protect the environment. The red soil regions located in Qassim province, Saudi Arabia were determined. Thirty red soil samples were collected from three regions (Al Bi'ithah, Dremeha and Al Bukaireyah). Gamma-ray spectrometry using NaI (Tl) detector was used to measure the radionuclides of ^{226}Ra, ^{232}Th and ^{40}K. The average (range) of activity concentration of ^{226}Ra was 10.0 (9.3–11.6) Bq/kg, 7.3 (6.6–8.4) Bq/kg and 19.4 (15.9–22.7) Bq/kg in Al Bi'ithah, Dremeha and Al Bukaireyah, respectively. For ^{232}Th, the average values of radioactivity concentration were 11.8 (7.6–13.0), 6.3 (5.1–7.3) and 19.1 (17.8–20.7) in Al Bi'ithah, Dremeha and Al Bukaireyah, respectively. In addition, the average radionuclide concentration of ^{40}K was 74.5 (71.2–78.3), 67.3 (57.6–77.4) and 94.3 (59.6–101.6) in Al Bi'ithah, Dremeha and Al Bukaireyah, respectively. Next, the comparison between radionuclide concentrations in this study and other published papers in the world was done. In addition, radiation hazard parameters were estimated. The maximum values of the radium equivalent and absorbed dose rate were 63.6 Bq/kg and 30.0 nGy/h, respectively. These values are lower than the international limit (370 Bq/kg and 65 nGy/h). Furthermore, the annual effective gamma doses and the lifetime hazards of cancer were lower than the international limit. The external hazard index (H_{ex}), internal hazard index (H_{in}) and representative level index ($I_{\gamma r}$) were found to be less than the acceptable limit of unity. Therefore, the study area is still in the zones of normal radiation level, which leaves the red soil radioactivity there less a threat to the environment as well as the human health.

1. Introduction

The major source of natural radionuclides in the environment is the weathering of terrestrial minerals and rocks and discharge associated with various industrial activities. The minerals and rocks consist of radionuclides like ^{238}U, ^{232}Th series, and ^{40}K that naturally decay and they produce ^{226}Ra, ^{222}Rn, polonium and lead. Regarding industrial activities, the radionuclides can be discharged into the environment when they are used to produce: (I) phosphoric acid, (II) oil and gas and (III) aluminum (Papatheodorou, Papaefthymiou, Maratou, & Ferentinos, 2005). The source of aluminum is bauxite containing high levels of natural radioactivity because it consists of both uranium (^{238}U) and thorium (^{232}Th) and their products (Cooper, 2005).

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Table 1 – Content of radionuclides in red mud [8].

Radionuclide	Specific activity (Bq/kg)
^{238}U–^{226}Ra decay series	100–3000
^{232}Th decay series	100–300
^{40}K	10–100

Natural radionuclides are present in rocks, soils, water, and minerals (El-Taher, 2012; El-Taher & Alashrah, 2015). They have become concentrated and exposed not only to the environment but also to human workers in mines, manufacturers, or water suppliers. Actually there are a number of authors who have studied the radiological impact resulting from phosphate production and oil or gas production (Abbady, Uosif, & El-Taher, 2005). The red soil has been widely used in industry and in scientific investigations such as bauxite, however the number of studies on the radiological impact resulting from red soil or red mud (the waste and tail material from primary aluminum production) was low (Jobbágy, Somlai, Kovács, Szeiler, & Kovács, 2009). Table 1 shows the radioactivity concentrations in the red mud. The radioactivity is high and it results from either or both ^{238}U and ^{232}Th decay series, depending on the geological composition. Natural radioactivity in the bauxite, solid residues and red soil resulting from alumina production in Western Australia was measured (Cooper, 2005). The ^{238}U activity concentration results were 120–350 (bauxite), 5–200 (soil residues) and 150–600 (red mud). Furthermore, the activity concentration of ^{232}Th was (450–1050), (300–800), (1000–1900) for bauxite, soil residues and red mud, respectively. The radionuclide concentration of red soil increases three times compared to the original bauxite mineral due to refined bauxite and produced alumina. The most concentration of uranium or thorium radionuclides is transferred to the solid waste. However, a few or none, of their radionuclides are found in the alumina. Furthermore, Righi, VeritàS, Albertazzi, Rossi, & Bruzzi (2009) measured the natural radioactivity in bauxite. Their results showed that the activity concentrations of ^{238}U were between 500 and 600 Bq/kg and from 400 to 450 Bq/kg for ^{232}Th.

The normal soil samples from seven cities including Al Bukaireyah in Qassim region were studied by El-Taher & Al-Zahrani (2014). They used gamma spectrometry to measure the radioactivity concentration of ^{226}Ra, ^{232}Th and ^{40}K. The mean activity concentrations of Al Bukaireyah for ^{226}Ra, ^{232}Th and ^{40}K were 8, 13 and 543 Bq kg^{-1}, respectively.

In this study, the concentrations of natural radionuclides in the red soil in three places in Qassim region are measured. This evaluation aims to: (I) Establish a reference level activity for radionuclide concentrations of ^{238}U, ^{232}Th decay series and ^{40}K in red soil samples around the mines (II) Calculate the radiological impact resulting from red soil (III) Compare the radioactivity concentration with other countries and (IV) Identify areas which may be a radiological hazard for the public.

2. Materials and methods

2.1. Location of study area

Al Bi'ithah (N27°56′, E43°43′) is located in the north-east of Buraidah in Qassim region. It is 180 km from Buraidah. It has a bauxite mine. It is laterite profile because it is rich in iron and aluminum. It is over a distance of 105 km in the scarp face of an early Cretaceous feature. The estimated total reserves are 101.8 million ton. Of course, the laterite development could be older than Oligocene. The thickness of bauxite is approximately 8.5 m described by Collenette and Grainger (1994). The Al Bi'ithah is in the cuesta region of central Saudi Arabia. Dremeha N(26° 16′), E(43° 7′) is located in the west of Buraidah in Qassim region. It is about 130 km from Buraidah and it has red soil. The third city is Al Bukaireyah located in the west of Buraidah and 15 Km from it. Also there are a number of published papers about Al Bukaireyah soil but they have not focused on red soil (El-Taher & Al-Zahrani, 2014).

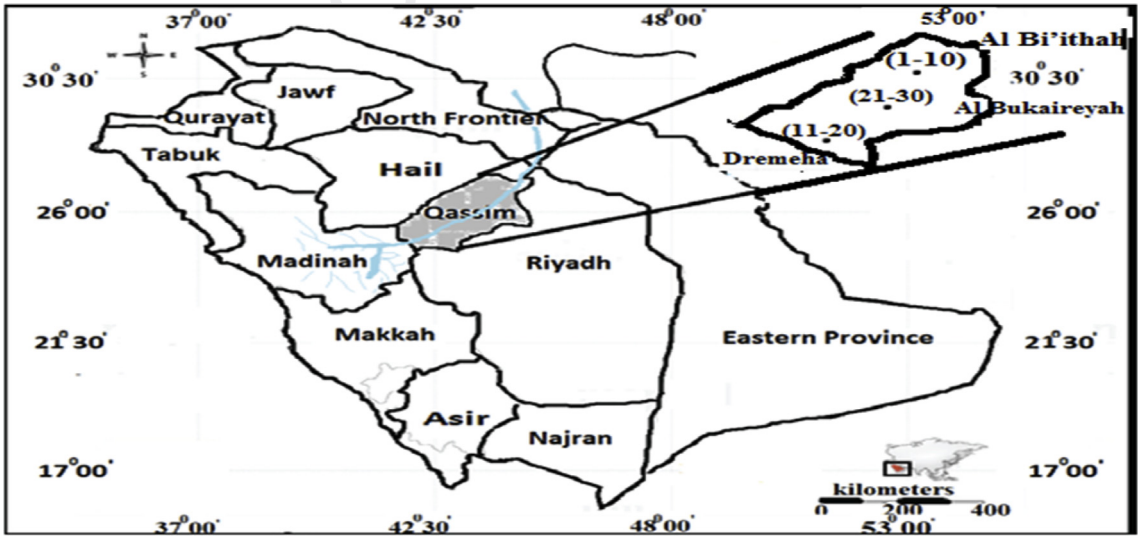

Fig. 1 – Location map of red soil area, Qassim province, Saudi Arabia.

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