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Determination of natural radioactivity and hazard in soil samples in and around gold mining area in Itagunmodi, south-western, Nigeria

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ABSTRACT

The activity concentrations of natural radionuclides ^{238}U, ^{232}Th and ^{40}K in soil samples from the gold mining area in Itagunmodi were measured by gamma spectrometry using Sodium Iodide detector. Radiological hazard assessments due to these natural radionuclides were carried out. The average activity concentrations of ^{238}U, ^{232}Th and ^{40}K determined in the mining sites were 55.3 ± 1.2, 26.4 ± 2.7 and 505.1 ± 7.1 Bqkg^{-1}, respectively while in the normal living areas it was respectively 8.8 ± 1.9, 17.5 ± 2.7 and 102.8 ± 12.1 Bqkg^{-1}. The mean annual effective dose in the mining site was 81.3 μSv which is about 16% higher than the world average. The mean radium equivalent activity concentration, the mean external and internal hazard indices in the study areawere less than the world averages. Therefore, mining activities in Itagunmodi poses no radiological hazard to the general public.

1. Introduction

Human environment is radioactive and human beings are exposed to radiation arising from sources including cosmic rays, natural radionuclides in water, air, soil and plants; and artificial radioactivity from fallout in nuclear testing and medical applications. The gamma radiation from natural radionuclides and cosmic rays constitute the external exposure while those derived from inhalation and ingestion through

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foods and drinking water constitutes internal exposure to humans. IAEA in 1996 estimated that 80% of doses contribution in the environment are derived from the natural radionuclides while the remaining 20% is from cosmic ray and nuclear processes. The natural radionuclides of concern in terrestrial environment are mainly potassium (^{40}K), uranium (^{238}U), thorium (^{226}Th) and the radioactive gas radon which is produced as these naturally-occurring radioisotopes decay. Radon emanates from the ground as a result of the direct decay of naturally-occurring radium and is a major source of radiation exposure (EPA, 2007). Natural radioactivity is widely spread in the earth's environment and depends primarily on the geological and geographical conditions, and appears at different levels in the soils of each region in the world (UNSCEAR, 2000).

Gold is most famous for its use in jewelry which is mostly due to its brilliant yellow luster and its never fading beauty. As a result, it has been used to adorn buildings, artwork, and furniture. Gold is formed deep within the earth's surface by a series of geological processes which involves extraction or mining. Radiation exposures arising in the mining and mineral processing industries are in three ways. These are external gamma radiation from ores, inhalation of dusts containing long-lived alpha-emitting radionuclides and inhalation of the short-lived decay products of radon (UNSCEAR, 2000). Inhalation of radon decay products in poorly ventilated underground mines can lead to exposures in excess of current radiation exposure limits, and this could cause high incidence of lung cancer in mine workers (UNSCEAR, 2000). Environmental problems associated with Naturally Occurring Radioactive Materials (NORM) in solid minerals mines and processing occur in the process of drilling, leaching, handling, storage, transportation of mineral ores and the use of contaminated equipment or waste media without controls. These usually lead to the spread of NORM contaminating the environment, resulting in potential radiation exposure of members of the public (Innocent, Onimisi, & Jonah, 2013). Due to the health risks associated with the exposure to NORM and inhalation of the short-lived decay products of radon, international bodies and governmental organization such as International Commission on Radiological Protection (ICRP, 1991) and Environmental Protection Agency (EPA, 2007) have adopted strong measures at minimizing such exposure.

Although literature showed that studies on radionuclide concentrations in mines have been extensively studied in Nigeria (Abdulkarim & Umar, 2013; Ademola & Ademonehin, 2010; Ademola, Hammed, & Adejumobi, 2008; Ademola & Obed 2012; Innocent et al., 2013; Jibiri & Esen, 2011; Nasiru, Zakari, & Abdullahi, 2013). Mining activities have not been subjected to radiological regulatory control and so there is generally little or no awareness and knowledge of the radiological hazards and exposure levels to NORMs in mining areas.

Our present study aimed at studying the natural radionuclides levels in the soil samples from the gold mining areas in Itagunmodi, south-western, Nigeria. This would be achieved by measuring the activity concentrations of ^{238}U, ^{232}Th and ^{4} K by gamma spectroscopy using NaI (Tl) detector in the representative soil samples, evaluating radiation hazard indices and the effective dose to the public from the soil samples.

2. Geology of the study area

Itagunmodi is located on latitude 7° 31° N and longitude 4° 39° E. It is about 347 m above sea level and has an approximate population of 12655. It is a town very close to Ile-Ife, Ilesa and Modakeke in Osun State, Nigeria (Fig. 1). The gold deposits in Itagunmodi, Osun State, Nigeria is located in the clayey soil types derived from variably migmatised gneiss, biotite-and-biotite-hornblende-gneiss and weathered amphibolites respectively (Adetoyinbo, Bello, & Hammed, 2011). The area is underlain by the Precambrian basement complex of the south-western, Nigeria and it is composed of gneisses, migmatites and Schist associated with amphibolites.

3. Materials and methods.

For this research, Itagunmodi was divided into five divisions. Four divisions (A – D) in the gold mining site and one division (E) in an undisturbed land where people live about 10 km from the mining site. This is done so that the activity concentrations in the mining site can be compared to the living area. Ten samples were collected from each division (A–D) and 20 samples from division (E) at a depth of 20–30 cm using an auger at the various locations. The collected samples were dried in an oven at a temperature of 105 °C overnight in order to remove any available moisture. After drying, the samples were crushed and sieved with a mesh having holes each of diameter of 0.2 mm in order to remove organic materials, piece of stones, gravel and lumps. Afterward, the homogenized samples were weighed and a mass of 200 g of each sample was packed in a cylindrical plastic container of height 7 cm and 6 cm diameter. The plastic containers were hermetically sealed with adhesive tape (AERB, 2003) for 30 days so as to allow for ^{238}U and its short-lived progenies to reach secular radioactive equilibrium (Veiga et al., 2006) before gamma counting.

3.1. *Activity determination*

The gamma-ray spectrometry set-up used in this analysis consists of a highly shielded and well calibrated 7.6 cm by 7.6 cm NaI (Tl) detector enclosed in a 5 cm thick lead shield to

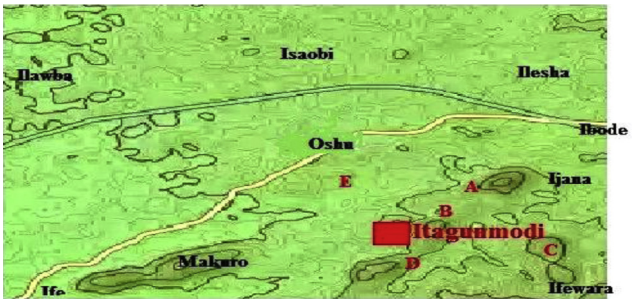

Fig. 1 – Geological map of the study area with the sampling location A–E.