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ORIGINAL ARTICLE

Radiometric evaluation of excessive lifetime cancer probability due to naturally occurring radionuclides in wastes dumpsites soils in Agbara, Southwest, Nigeria

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Abstract The concentration and spatial distribution of the gamma ray emitting ^{238}U, ^{232}Th, ^{40}K and ^{137}Cs radionuclides in dumpsite soils in Agbara were analyzed with the aim of evaluating the radiation hazards and excessive lifetime cancer risk using well calibrated HPGe γ-ray spectrometry technique. The ranges of activity concentrations of ^{238}U, ^{232}Th, ^{40}K and ^{137}Cs are $11.5 \pm 1.0 \leftrightarrow 166 \pm 40$ Bq kg^{-1}, $15.6 \pm 1.8 \leftrightarrow 31.4 \pm 2.3$ Bq kg^{-1}, $20.4 \pm 1.3 \leftrightarrow 366 \pm 30$ Bq kg^{-1} and $0.52 \pm 0.1 \leftrightarrow 8.44 \pm 0.2$ Bq kg^{-1} respectively. Radiological parameters such as absorbed dose rate, radium equivalent, annual effective dose equivalent, internal and external hazard indices, gamma level index, activity utilization index, annual genetic significant dose equivalent, exposure rate and excessive lifetime cancer risk were calculated to know the complete radiological hazardous nature of the dumpsite soils to the inhabitants of the sites. The calculated radiological parameters were higher than the world average value in two of the sampling points. The ratio of the detected radioisotopes was calculated for spatial distribution of natural radionuclides in the study area. RESRAD computer code was applied to calculate the total effective dose equivalent (TEDE). The code was also used to calculate the probability of excess lifetime cancer incurred by dwellers/inhabitants of the dumpsites, the level of which was determined to be 0.5×10^{-4} and 2.5×10^{-5} for Idowale and Ibijola dumpsite soils over a period of 30 years respectively. Therefore, the radiological risks to the general populations from waste enhanced naturally occurring radioactive materials (WENORM) from the Idowale dumpsite top soils are considered to be significant.

1. Introduction

There has long been concern about the issue of soil pollution by radionuclides and heavy metals because of their severity of toxicity for plant, animal, human beings, environment and

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their lack of biodegradability in the environment. Soil is a primary recipient of many of the waste products and chemical used in modern society. Soil is the primary reservoir of radionuclides and other pollutants in the atmosphere, hydrosphere and biota, and thus plays a fundamental role in the overall nuclide cycle in nature (Cao et al., 2010). Soil is an important environmental media that sustain life, one of the ways soil can be polluted is through improper disposal of hazardous wastes. Radioactive materials in soil pose potential threats to the environment and can damage human health through various absorption pathways such as direct ingestion, dermal contact, and diet through the soil–food chain, inhalation, and oral intake (Lu et al., 2011).

Human activities create wastes and the way these are handled, stored, collected and disposed can give rise to impacts on the environment and public health (Ademola et al., 2015). Hazardous waste can cause pollution, damage to health and even death. The environmental problem posed by solid wastes which are improperly disposed in most cities and town has been of concern to federal, state local and community development authorities in Nigeria. Poor waste management poses several challenges to the well-being of city residents due to the potential of the waste to pollute water, food sources, land, air and vegetation (Njoroge, 2007), when the wastes are not properly managed or disposed (Porteous, 1985).

Hazards posed by such waste dumpsite are not only in term of odor and presence of disease causing micro-organism, but can arise from the radiation emanating from such dumpsite (Ojoawo et al., 2011), which occur as results of accumulation and reaction of different radioactive materials in the waste indiscriminately dumped on open waste site. At waste dumpsites, there are possibilities for radiation to be emitted due to the presence of radioactive waste in the landfills as well as naturally occurring radionuclides in the soil. The radioactive contamination of soil, water and air can be transferred to humans through the soil via plants (^{40}K) or through inhalation (^{222}Rn and ^{220}Rn). These radionuclides even at low concentrations can have potential impacts on the environmental quality and human health and may pose a long term risk (Ademola et al., 2015). Moreover, risk assessment which is an effective scientific tool will enable decision makers to manage sites so contaminated in a cost-effective manner while preserving public and ecosystem health (Zhao and Kaluarachchi, 2002). Therefore, objectives of this study were to determine the concentration of waste enhanced naturally occurring radionuclides (WENORM) present in representative soil samples from some selected waste dumpsites in Agbara by gamma-ray spectrometry in order to estimate the, excessive lifetime cancer probability, radioactivity disequilibrium and other radiological hazard indices from these dumpsites to the general public and provide a reliable baseline data for future radionuclide evaluation in the area.

2. Material and methods

2.1. Description of the study area

Agbara which is an industrially populated town in Ogun State is located within latitude 6°20′0″ N and 6°35′0″ North of the Equator and longitude 3°5′0″ E and 3°10′0″ East of the Greenwich Meridian (Fig. 1). The area stands on a low-lying gent undulating terrain with altitude ranging between 30 and 80 m above sea level. The area is characterized by high annual temperature, high rainfall, high evapotranspiration and high relative humidity which make it to be classified as humid tropical region (Akanni, 1992). The prevailing wind direction was Southwesterly at the period of study (wet season period–June–October) while the prevailing wind speed ranged range between 2.52 to 3.55 m s^{-1}. The prevailing wind direction in the dry season (November–March) is Northeasterly. Two major municipal dumpsites soils of about 3 m thickness and covered an area of 10,000 m^2 were used and they are Ibijola dumpsite along Ibijola hospital way and Idowale dumpsite (major) along Idowale road dumpsite.

2.2. Sample coding

The soil samples were coded as follows in order to prevent identification error. The sample codes consist of four alphabets. The first alphabet stands for the study area (Agbara), the second alphabet stands for representative soil samples (A, & B), and the last two alphabets stands for the soil layer type e.g. TS which connotes Top Soil and SS which connotes Sub Soil. All soil samples were controlled with a control sample different from the above stated soil samples, this was done in order to know the contamination level and dose rate of radionuclide in these dumpsite soils compared to that of the dumpsite free soil (control soil samples) that was collected at about 40 km from Idowale dumpsite within the same geological formation with Ibijola dumpsite. AA stands for Idowale dumpsite soils while AB stands for Ibijola dumpsite soils.

2.3. Sample collection and preparations for radiochemical analysis

A total of ten (10) soil samples were obtained from the two major dumpsites in the study area and a waste free control samples within the same geological formation with the two selected dumpsites using a hand-driven stainless steel soil auger. Firstly with a garden rake, the waste was removed to expose the soil under the waste dumps from where samples were collected. Five sets of soil samples were collected from each of the dump sites (Idowale and Ibijola). At each location, the dumpsite was divided into two sections. In each section, five soil samples were collected and composited to obtain a representative samples using coning and quartering technique. This implies that five composite or representative samples were obtained from each dumpsite under investigation. The soil samples were taken at about 0–15 cm depth (using a meter rule) by the use of stainless steel hand-driven soil auger, and taken to the laboratory in labeled polythene bags stored and were air-dried at laboratory temperature in order to avoid cross contamination or pollution of the samples. The samples were then pulverized by grinding, and filtered through a 2 mm mesh sieve. Two hundred grams (200 g) of pulverized soil samples was subsequently measured using an analytical weighing balance with a precision of ±0.01 g and packed into cylindrical containers (beaker) which were carefully labeled. These samples were safely conveyed to Natural Institute of Radiation Protection and Research, University of Ibadan, Ibadan, South-West Nigeria, at the laboratory the plastic were hermitically sealed with adhesive tape and kept for minimum of

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