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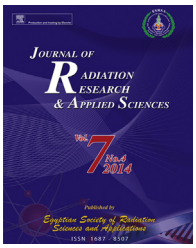

Assessment of radiation exposure levels at Alaba e-waste dumpsite in comparison with municipal waste dumpsites in southwest Nigeria

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ABSTRACT

Radiation exposures at the e-waste dumpsite around Alaba International Market, Lagos and three municipal waste dumpsites located in Ibadan and Ado Ekiti, southwest Nigeria were assessed by gamma ray spectroscopy using a highly shielded Canberra NaI (Tl) detector. Soil samples were collected for analysis at the municipal waste dumpsites for comparison with e-waste dumpsite. Samples were also collected at a location free from waste dumps to serve as control. The mean concentrations of ^{40}K, ^{226}Ra, and ^{232}Th obtained at the e-waste dumpsite were lower than those obtained at the municipal waste dumpsites and the controls site. The values obtained at the e-waste dumpsite were also lower than the world average values of 412 Bq/kg, 35 Bq/kg and 30 Bq/kg for ^{40}K, ^{226}Ra, and ^{232}Th, respectively as reported by UNSCEAR. The mean annual effective dose rate obtained for the soil samples from e-waste dumpsite, Oritaperin, Ring-road and Ilokun dumpsites were respectively 0.026 mSv, 0.074 mSv, 0.080 mSv and 0.093 mSv/yr. The mean absorbed dose rate at the e-waste dumpsite was 21.12nGy/h which is lower than the world average of 60nGy/h. Values for other hazard indices were below the world average and lower than their respective minimum permissible limits. Hence, e-waste and municipal waste does not pose any immediate radiological risk to the people working/living in the vicinity of the dumpsites.

1. Introduction

The use of electronic devices has become so popular especially in this era of information technology (IT) globally. The dependence on, and the vital role that information and communication technology (ICT) is playing in the world economy has brought about an increase in the use of electronic equipment (Odeyingbo, 2011). The rapid growth in IT has led to a continuing improvement in the capacity of electronic products but at the same time, a decrease in the product's lifetime (Nnorom, Osibanjo, & Nnorom, 2007). Old and

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abandoned phones, computers and other electronic products usually end up as waste in dumpsites. They are called electronic waste (e-waste). The United Nation Environment Program estimates that 20–50 million tons of e-wastes are produced globally every year (Puckett, Westervelt, Gutierrez, & Takamiya, 2005; Robinson, 2009) and the world is faced with new environmental challenges due to poor management of e-waste generated/imported by developing countries. Nigeria's e-waste generation is by far the highest in all of West African Countries (Andreas, Oladele, Adeyinka, & Siddharth, 2011). Health and safety concerns associated with e-waste generation include: inhalation of toxic fumes (from Pb, Cd, Hg etc.), contamination of soil and ground water and potential exposure to radiation from ashes, smoke and dust from the dumpsites. Since Nigeria has no data on the radiological status of these dumpsites, no routine monitoring mechanism to check radiation levels in e-waste sites and no effective regulation on the importation of e-waste, it is necessary to carry out this research study to forestall the possibility of radiation accident as experienced in Mayapuri- India.

Human beings are continuously exposed to ionizing radiations which are naturally present in the environment. In the last few decades, the natural inventory of radionuclides has been increased due to human activities. Waste generation and disposals have also contributed in no small measure to the increased levels of human radiation exposures. Human radiation exposure could either be external due to the concentrations of ^{40}K, ^{226}Ra and ^{232}Th in soil or internal due to inhalation of radon and its progenies in dust and fumes from waste disposal sites. The world-wide average specific activity of ^{40}K, ^{226}Ra and ^{232}Th in the earth's crust is estimated to be 412, 35 and 45 Bqkg^{-1}, respectively (UNSCEAR, 2008). These values give an average outdoor dose of 60 nGy h^{-1} at a height of 1 m to the ground. Knowledge of radiation exposure levels at waste dump-sites enables one to assess any possible radiological risk to human health and environment due to waste generation and disposal.

Radionuclides contents of soil samples collected from various waste dumpsites have been studied by many researchers in Nigeria (Ademola, Babalola, Alabi, Onuh, & Enyenihi, 2014; Avwiri & Olatubosun, 2014; Emelue, Eke, Oghome, & Ejiogu, 2013; Faweya & Babalola, 2010; Isinkaye & Faweya, 2006; Odunaike, Laoye, Alausa, Ijeoma, & Adelaja, 2008; Oladapo, Oni, Olawoyin, Akerele, & Tijani, 2012). Their results indicated that the activity concentrations of ^{40}K, ^{226}Ra and ^{232}Th in dumpsites show no significant radiological health hazards to the population around the dumpsites. But in most cases, moderate increases were observed at the dumpsites in comparison with control sites free from waste disposal. On the national and global scale, little had been done on the radiological health implications of natural radionuclides in e-waste dumpsites. The main objective of the present study is to evaluate the activity concentrations of ^{40}K, ^{226}Ra and ^{232}Th in soil samples from e-waste dump-site as compared to municipal waste dump-sites in southwest Nigeria in order to assess the radiological implications on the population around the dumpsites. This study therefore will be useful for establishing a baseline data on natural radionuclides present in Alaba international market e-waste dumpsite.

2. Materials and methods

2.1. Study area

Alaba international market is located in Lagos State, Nigeria. Lagos is the largest city in the whole of Africa with two seaports that serve as a trade portal not only to Nigeria but to the rest of West Africa. It is situated in a flat, coastal, dense forest area with swamps, marches and lagoons. Lagos with a population of about 17.5 million people has a tropical climate with moderate temperature and relative humidity and very importantly, a low water table. This implies that hazardous waste can easily leach and contaminate the ground water.

Alaba international market is the largest electronics market in West Africa. The market was established in 1978 and occupies a land area of approximately 2 km^2 in the southwestern part of Lagos. The market features more than 2500 shops doing refurbishing and offering used electrical and electronic products for sale. Many of these products include end-of-life electronics devices such as mobile phones, television, computers, microwave oven, fridges, air conditioners etc. that are made up of heterogeneous mix of metals, ceramics, glasses and plastics. A major dumpsite (about 100 m^2 in size) is located outside the market where e-waste collectors and recyclers work and indulge in burning and other crude recycling practices without care for their health or environment, in an attempt to recover some useful parts/scrap from e-waste. Due to congestion, makeshift structures are erected on the site to accommodate the teeming population.

The other sampling sites are located entirely in the basement complex geological region of southwest Nigeria. The basement complex of Ibadan and Ado Ekiti comprise of quartzites, banded and augen gneisses, granite gneiss and migmatite. The minor rocks include pegmatite, aplite, quartz veins and doleritic dykes (Oyawoye, 1972; Rahaman, 1976, pp. 41–58). Igneous rocks, which are predominant in these areas generally exhibit higher radioactivity than sedimentary rocks found in most parts of Lagos. Fig. 1 shows the map of southwest Nigeria indicating the sampling locations.

2.2. Sample collection and preparation

In all, 45 soil samples were collected from the waste dumpsites consisting of 20 from e-waste, 10 from Oritaperin, 5 from Ring road and 10 from Ilokun dumpsites (Table 1). The size of the dumpsite dictates the number of samples collected. Two samples were collected from a reference site (free from waste disposal) located close to the e-waste dumpsite to serve as control. All the soil samples were separately packed in black polythene bags, labeled, and safely conveyed to Radiation and Health Physics Laboratory of Physics Department, University of Ibadan. At the laboratory, they were sun dried to attain constant weight, pulverized, and sieved using a 2 mm mesh sieve. Two hundred grams (200 g) of each sample was subsequently measured using an electronic weighing balance and packed in plastic containers of diameter 6.6 cm to sit with good geometry on NaI(Tl) detector used for the measurements. The plastics were hermitically sealed with adhesive