Radioactivity and Radiological Risks of Soil Exposure to Workers: a Case Study of Production Company in Ota, Ogun State, Nigeria

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Abstract

Background dose assessment has been carried out in and around a production company using Gamma Ray Spectrometer (Super Spec. 125 model). This was done to identify the zones that could pose health risks to workers. The geospatial maps for easy identification of radionuclides occurrence in the factory was determined using geospatial analysis. The highest exposure dose was found at the restaurant and factory areas whereas the lowest background dose was noted at the entrance of the company. The absorbed dose rate of 199.88 nGy/h is 0.4 % higher than the world average value according to UNSCIAER, 2000. The geospatial analysis revealed that the natural radionuclides in the region have a trend, NW-SE trending with significant re-deposition at the western part. This could be caused by the diffusion of chemical weathering and complexation of Dahomey (Benin) basin soil geology from human activities. The boxplot identified the radionuclides distributions which are in the order of magnitudes $^{40}$K > $^{238}$U > $^{232}$Th in the study area. Significantly, the geospatial analysis of the background gamma dose rate has revealed the hot spots in the area which may pose health risk to the workers if adequate measure is not taken to advise workers not to spend much time at the hot spot zone.

Keywords: Radionuclides, Gamma Dose Rate, Iso-dose map, Geospatial Analysis

1.0 Introduction

The existence of natural background radiation on the planet has been since the formation of the planet. All living organisms are exposed continually to this ionizing radiation [1]. The three basic radioactive elements: Potassium (K), Uranium (U), and Thorium (Th) and several other radioactive elements such as Rubidium (Rb), gamma rays etc which are generated when they decay or decayed to daughter isotopes that subsequently decay, are responsible for this ionization radiation. Their sources terrestrial and cosmic radiation [2] can cause external and internal exposure [3]. The terrestrial radiation is composed of primordial radionuclides such as $^{40}$K, $^{87}$Rb, $^{238}$U, $^{232}$Th, $^{235}$U present in air, soil and water and varies quantitatively depending on the geological and geographic
characteristics of the region [4,5]. The Cosmic radiation depends on altitude and magnetic latitude and is constituted by primary and secondary cosmic rays [6]. The changes in concentrations of the naturally occurring radionuclides of uranium–thorium series and their decay products, as well as potassium-40, may vary the public external dose from terrestrial radiation [6].

The estimation of preliminary background radiation in and around covenant University and its absorbed dose-rate using survey radiation meter and sample collection has been found to range from 200 to 14000 nGyh-1 [5]. This value is however 3-233 times higher than the world average value of absorbed dose rate of 60 nGyh-1 [6] and as well more than the values reported elsewhere in related background assessments [7]. It has shown that no extensive geospatial mapping and laboratory analysis of background radiation of soil exposure to the inhabitants of the region. The low cost of In-situ gamma ray spectroscopy is the radiometric representative approach for rapid assessment exposure dose as well as the radioactivity of the laboratory based technique. A mobile system backpack detector is used for detailed radiometric survey in areas with minimum vehicle access with high resolution which depends on the density of the measurement [8]. This study is aimed at evaluating the exposure dose and radioactivity of naturally occurring radionuclides in soil within the production company using geospatial mapping method of In-situ gamma ray detector and laboratory gamma spectroscopy method.

2.0 Geographical Location and Geology of the Study Area

This Production Company is in Ota, OgunState, Nigeria which falls within the Eastern Dahomey (Benin) Basin of south-western Nigerian that stretches along the continental margin of the Gulf of Guinea. Rocks in the Dahomey basin are Late Cretaceous to Early Tertiary in age [9]. The stratigraphy of the basin has been classified into Abeokuta Group, Imo Group, Oshoshun, Ilaro and Benin Formations. The Cretaceous Abeokuta Group consists of Ise, Afowo and Araromi Formations consisting of poorly sorted ferruginized grit, siltstone and mudstone with shale-clay layers.
3.0 Materials and Method
3.1 Natural Background Radiation Measurements

The background measurements within the study area were carried out for a weeks between 7 am to 5 pm daily. The instrument utilized for this investigation is the compact hand held radiation locator (Super SPEC RS 125). This instrument is most reasonable for the identifying normally happening radionuclides and portion presentation to the under-studies living around the landfill site zone. The hardware has high exactness with plausible estimation mistakes of about 5%. It offers an incorporated structure with a huge locator, direct examine readout, information stockpiling, full climate assurance, convenience and high affectability.

The all out check show of RS-125 Super SPEC on the front board in cps at 1/sec refresh rate. It has a boisterous direct sound allowing eyes free task. It has USB headphone support for boisterous territory reviewing, the variable rate SCAN method of RS-125 Super SPEC stores information in memory or yields by means of Bluetooth to an outside capacity gadget. Outside GPS is incorporated into the information stream by means of Bluetooth association with give area information.

The measure method of RS-125 Super SPEC gives test focus examination direct information show of K (%), U (ppm) and Th (ppm). It likewise possesses client selectable example energy for ideal examination. The RS-125 Super SPEC is given utility programming to download the information that is put away in memory. All
information in memory is yield through Bluetooth or USB to the RS-Analyst program on a PC. This may take the gathering of 1024 channel spectra, measure information or output information + GPS. The program likewise gives graphical and numeric perspectives on the information. The information can likewise be re-sent out as a content document enemy further handling.

Thirty three stations were estimated in the investigation territory; the radiation identifier was held 1 meter over the ground at each purpose of estimation, readings were taken multiple times at each station and their normal determined to guarantee precision. Prior to initiation of estimation for the investigation, the instrument is enabled 15 to 30 minutes rest to balance out as taught by the makers to guarantee precise outcomes. At each station the GPS arranges were noted. The separation between two stations was around 12 meters.

Readings were taken at an internim of 90 seconds at every session. The instruments perusing was in parts per million (ppm), the mean outcomes were acquired and after that changed over to Becquerel per kilogram (Bqkg⁻¹). Readings were not taken around zones of vegetation to keep away from obstruction. Microsoft exceed expectations programming was utilized for the transformation investigation.

3.2 Geospatial Analysis of the Absorbed Gamma Dose Rate Mapping in the Study Area

The gamma absorbed dose rate measured in the air 1 m above the ground were coded on the geo-reference topographical of the region. The longitude, latitude and elevation of each point were measured using Garmin 62 GPS. The Iso-dose map of the background natural radiation was created using ArcGIS 10.01 by applying Kriging interpolation method which reveals the linear estimation of gamma dose rate values and its distribution around the area. The global geodetic system of 1984 (WGS84) was adopted for the reference system of mapping the isoline according to [3,10].

4.0 Results and Discussion

4.1 Activity Concentrations of $^{238}$U, $^{232}$Th and $^{40}$K in the Soil Sample along Three Profiles

Figures 2 to 4 present the comparisons of the activity concentrations of $^{238}$U, $^{232}$Th and $^{40}$K in three different profile lines measured in the study area at Ado-odo Ota in Ogun State. Figure 2 however compared the ranges of the activity concentration of $^{40}$K and $^{233}$Th along profile 1 which can be observed that the ranges of $^{40}$K vary from 460 to 680 Bqkg⁻¹ whereas that for $^{233}$Th varies from 50 to 75 Bqkg⁻¹. It signifies from the plot that the activity level of $^{40}$K was more dominance compared to the $^{233}$Th activity level in the study area. This plot indicates that $^{40}$K level attributed to the higher gamma dose along the profile compared to $^{233}$Th in the study area.

When considering Figure 3, it compared the activity concentrations of $^{40}$K and $^{238}$U in the study area with the ranges of $^{40}$K vary from 489 to 650 Bqkg⁻¹ whereas that for $^{238}$U varies from 50 to 75 Bqkg⁻¹. This plot indicates that $^{40}$K could still be attributed to the high background dose along that axis when compared to $^{238}$U in the study area.

Along profile 3 line, the activity concentrations of $^{238}$U and $^{232}$Th this study site are shown in Figure 4 with the activity concentration of $^{238}$U vary from 33 to 64 Bqkg⁻¹ whereas that for $^{232}$Th varies from 60 to 73 Bqkg⁻¹. This profile 3 plot revealed that $^{232}$Th is more contributed to the more gamma dose compared to $^{238}$U in the study area.
site. As for the dose rate in Figure 4, it can be noted that the highest concentration background dose is located in station 3 of profile 2 in the study area, while the lowest concentration is located in station 8 of profile 3 line in the area of study.

**Figure 2:** The Activity Concentrations of $^{40}$K and $^{232}$Th in the study area

**Figure 3:** The Activity Concentrations of $^{40}$K and $^{238}$U in the study area
Figure 4: The Activity Concentrations of $^{238}\text{U}$ and $^{232}\text{Th}$ in the study area

Figure 5: Plot of Dose Rate against the Stations of Survey Area

4.2 Geospatial Analysis of the Background Dose Rate Distribution in the Study Area
The gamma dose rate, which is the background contribution effect of $^{238}\text{U}$, $^{232}\text{Th}$ and $^{40}\text{K}$ are shown in Figure 5 below. It can be seen that the effect of $^{232}\text{Th}$ and $^{40}\text{K}$ shave off the higher clusters of $^{238}\text{U}$ distribution in the area shown in Figure 5. It can be observed that from the middle to the extrem parts of NW and the extrem parts of SE indicate the highest exposure risks to the workers. Trending down towards the upper and lower parts indicate moderate to low background dose. The colour coding on the legend was used to accurately represent the dose rate ranges based on the regulatory limit criteria according to global average external background dose rate of 80 nGyh$^{-1}$ and the general public dose rate limit of 114 nGyh$^{-1}$ respectively [6,11-14].

Figure 6: Geospatial distribution of Dose rate in the Study area

5.0 Conclusion

Background dose assessment has been carried out in and around May & Baker Pharmaceutical Company using Gamma Ray Spectrometer (Super Spec. 125 model). The absorbed dose rate of 119.88nGry/h is 0.4 % higher than the world average value according to [6,11-14]. The geospatial analysis revealed that the natural radionuclides in the region have a trend, NW-SE trending with significant re-deposition at the western part of
the study area. This could be caused by the diffusion of chemical weathering and complexation of Dahomey (Benin) basin soil geology coupled with human activities. The activity concentrations identified the radionuclides distributions which are in the order of magnitudes $^{40}$K $> ^{238}$U $> ^{232}$Th in the study area. Significantly, the Iso-Dose maps have revealed the hot spots in the area that could be hazardous to the workers if adequate measure of decontaminating the May & Baker Environment is not made. This study could be useful in monitoring the radiation related activities in industries for occupational health hazard policy as well as the suitable sites for factories and offices.

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