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ESTIMATION OF NATURAL RADIOACTIVITY LEVELS IN BEACH SANDS FROM LAGOS, SOUTH-WESTERN NIGERIA

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ABSTRACT

Analysis was done on sand samples collected from six prominent beaches in Lagos coastline of Nigeria that are used as tourist centre for holiday makers and other activities. Recently there has been great concern about the health risks associated with exposure due to natural radioactivity present in our environment. This study investigates the levels of hazards associated with the primordial radionuclides in the unstoppable beach sands. In this context, analysis for natural radioactive isotopes such as ^{238}U, ^{232}Th and ^{40}K in beach sands assayed were carried out using gamma ray spectroscopy Nal(Tl) scintillation detector. The results show the specific activities in the range 31.58 $\pm$ 5.20. to 11.64 $\pm$ 2.53, 53.50 $\pm$ 5.40 to 17.6 $\pm$ 3.70 and 182.50 $\pm$ 3.17 to 67.80 $\pm$ 1.6 respectively. The outdoor gamma dose rates were determined by Alarm Dosimeter Geiger counter portable device and measurements were taken in air for two minutes at 1m from the ground. The mean value of absorbed dose rate, annual effective dose, radium equivalent activity, internal and external hazard indices determined due to activity concentrations are: 31.17 $\pm$ 4.51, 38.23 $\pm$ 5.53 and 67.15 $\pm$ 9.66, 0.24 and 0.18 respectively. No fallout was detected. The results are within the values found in literature and show that the natural radionuclides in samples of the beach sand do not pose any significant risk to tourists and other holiday makers. Sand from the beaches is also safe for use as construction material, shown the relevance in terms of the radiological quality of the beaches from both human and environmental safety.

KEYWORDS: Natural Radioactivity, Human and Environmental

INTRODUCTION

The naturally endowed and prominent beaches in Nigeria are mostly found in Lagos coastline. These beaches are used as a tourist center for holiday makers and important recreation centers for large number of people from many countries around the world. It provides a sense of relaxation and calmness to the minds and bodies of tired travelers. This study is required because past studies revealed that certain beaches in south America present high radiation due to the presence of monazite sand (B.A.S, 1997). Monazite is considered an important geological material (Hassan et al, 1997). Around the world, several authors have been studying radionuclide concentrations in sand beaches in Kerala Nadu coastal region of India (Radhakrishna et al.,1993),in Bangladesh (Alam et al.,1999) and in the south-western Australia(de Meijer et al.,2001).Also in India,Kannan et al.(2002) analysed the distribution of natural anthropogenic radionuclides in beach sand and soil from Kalpakkam area using gamma ray spectrometry. Hence this study was necessitated by the fact that no previous work has been conducted to provide a distribution of radionuclides and their concentration in beach sands along the coastline in Lagos state of Nigeria. Therefore, the objective of the present study is to measure the concentrations of natural radionuclides in an extensive selection of beach sands collected from Lagos coastline of Nigeria using gamma spectrometer to determine the concentrations of ^{238}U, ^{232}Th and ^{40}K and the relative hazards associated with the use of the beaches as tourist resorts as well as using the beach sands as construction materials (UNCEAR, 1993; Radhakrishma et al.,

1993; De Meijer et al., 2001.

Experimental

The study was carried out at the Radiation and Health of the Department of Pure and Applied Physics, Ladoke Akintola University of Technology, Nigeria. January 2015 to June, 2015.

MATERIALS AND METHODS

One hundred and eighty beach sand samples were collected from the six beaches investigated thirty samples from each weighing 1.00kg. The mean of the thirty measured samples was calculated and appointed as the activity concentration of the beach. The outdoor gamma dose rate took the same procedure. The coordinate of the reading were done by Global Positioning System, the samples were dried in an oven at a temperature of 35^0C for 24 hours to ensure that moisture was removed from the samples. Representative samples were packed into polyethylene cylindrical containers of 95mm diameter and 38mm height.

Table 1: Coordinate of the Study Area

Beaches	LATITUDE	LONGITUDE
LEKKI	N 6^O 26^1 49^{11}	E 3^0 31^1 43^{11}
BAR	N 6^0 25^1 3.58^{11}	E 3^0 25^1 44.79^{11}
ONIRU	N 6^0 25^1 52^{11}	E 3^0 24^1 57^{11}
ALPHA	N 6^0 25^1 19^{11}	E 3^0 31^1 23^{11}
ELEKO	N 6^0 28^1 11^{11}	E 3^0 49^1 45^{11}
COCONUT	N 6^0 27^1	E 3^0 16^1

The packed samples were tightly sealed and kept for 28 days to attain a state of secular equilibrium between radon and its decay products. The samples were thereafter counted for a period of 36000s, using a gamma spectrometry system with NaI (TI) as the detector.

The scintillation detector, a 3x3 inch NaI (TI), a product of Princeton Gamma Tech. USA was placed in a lead shield to reduce the effect of background radiation. Energy and efficiency calibrations of the detector were carried out using a standard source traceable to Analytical Quality Control Services (AQCS), USA; which contains ten radionuclides of y-emitters with energies ranging from 59.54 to 1836keV.

The activity concentration of ^{238}U was determined from the 63.3 KeV peak of ^{234}Th, ^{226}Ra was determined from the average activity concentration of 295.3KeV of ^{214}Pb and 1764.5 KeV of ^{214}Bi. The activity concentration of ^{234}Th was determined from the average concentration of ^{212}Pb (238.6 keV), ^{228}Ac (911.1 keV) and ^{208}Tl (2614.7 keV), and that of ^{40}K 1460.0 keV. The activity concentration of ^{235}U was determined from the 185.7 keV gamma line, which were corrected by removing the contribution from the 186.2 keV of ^{226}Ra using the following equation.

$$A\,(^{238}U) = \frac{N_{186} - A(^{226}Ra)\,.\,f_E\,(^{226}Ra)\,.\,\eta_{186}\,.M\,.Tc}{\eta_{186}\,.\,f_E(^{235}U)\,.\,M\,.\,Tc} \quad (1)$$

Where, N_{186} is the total counts for the 186 keV doublet. A (^{235}U) and A(^{226}Ra) are the activity concentrations of ^{235}U and ^{226}Ra respectively, η_{186} is the detection efficiency of the 186keV line, f_E(^{235}U) and f_E(^{236}Ra) are the emission probabilities of the 185.7 and 186.2keV gamma lines of ^{235}U and ^{226}Ra respectively. T_c is the counting time and M is the mass of sample.

The Minimum Detectable Activity (MDA) for each radionuclide ^{226}Ra, ^{232}Th and ^{40}K was calculated using the following equation:

$$MDA = \frac{1.645\sqrt{N_B}}{f_E \cdot \eta(E).t_C \cdot M} \quad (2)$$

Where, 1.645 is the statistical coverage factor at 95% confidence level, N_B is the background counts at the region of interest, t_C is the counting time, f_E is the gamma emission probability, ŋ(E) is the photopeak efficiency and M is the mass of sample. The MDA for each of the radionuclide were calculated as 0.30Bq/kg for ^{238}U, 0.12Bq/kg for ^{226}Ra, 0.11Bq/kg for ^{232}Th and 0.9Bq/kg for ^{40}K respectively.

Calculation of the Absorb Dose Rate and Annual Effective Dose: the absorbed dose rate at 1m above the ground (in nGy/h) due to U-Th series and ^{40}K was calculated using the following equation;

$$D\left(\frac{nGy}{h}\right) = \sum_{i=1}^{n} A_i \cdot DCF \quad (3)$$

Where DCF are the dose coefficient in nGy/h per Bq/kg taken from UNCEAR (2000) report (UNCEAR, 2000) and A_i are the activity concentrations of the radionuclides.

The annual effective dose equivalent, $H_{E,}$ from external exposure to gamma rays from the soil samples sand was calculated from the absorbed dose rate using the expression (UNSCEAR, 2000):

$$H_E = D(nGy/h)* 8760(h)* 0.2 * 0.7(Sv/Gy) \quad (4)$$

Where, 0.2 is the occupancy factor for outdoor, 8760 is the total time of the year in hours and 0.7SvG/y is the conversion factor for external gamma irradiation.

Radium Equivalent Activity.

The exposure due to the γ radiation, defined in terms of the radium equivalent activity Ra_{eq} is given by equation (2) (Faheem *et al*, 2008)

$$Ra_{eq} = A_{Ra} + 1.43\ A_{Th} + 0.077\ A_K \leq 370 \quad (5)$$

According to this formula, 1Bq/kg of ^{226}Ra, 0.7Bq/kg of ^{232}Th and 13 Bq/kg of ^{40}K yield the same γ ray dose. The radium equivalent activity for the material analyzed in this work was calculated and a value of 53.80 Bq/kg was obtained. This value is much lesser than the standard limit of 370Bq/kg. By (UNSCEAR).

RESULTS AND DISCUSSIONS

The results of measurement of the radionuclides concentrations of the beach sand samples collected from six prominent beaches in Lagos coast line of Nigeria are presented in Table 2. Activity concentration values of ^{40}K ranges from 67.80Bq/Kg to 182.50 Bq/Kg, ^{238}U from 11.64Bq/Kg to 31.58Bq/Kg and ^{232}Th from 17.60Bq/Kg to 53.50Bq/Kg.

Substitution of these values into equation 3 gives the mean absorbed dose rate due to the three natural radionuclides as 31.17±4.5 for the six beaches. A conversion factor of 0.7SvGy-1 was employed to convert the absorbed dose rate to human effective dose equivalent with an outdoor occupancy of 20% on the absorbed dose rate that arrived at the mean annual effective dose equivalent of 38.23± 5.53µSv/y for the study areas.

The radium equivalent activity values ranged from 45.69±9.41 to 116.80 ±1.71 using equation 5.These values are

less than the maximum admissible standard by UNCEAR (2000) for absorbed dose rate, annual effective dose equivalent and radium equivalent are 55nGy/h, 70μSv/y and 370Bq/Kg respectively. Also, the radiation hazards, both internal and external were less than unity so as to keep radiation hazard insignificant (Beretka et al., 1985).

However, in this present work, table 3 above shows the result of the calculated absorbed dose rate and measured outdoor dose rate, annual effective dose and radium equivalent.

Table 2: ^{238}U, ^{232}Th And ^{40}K Mean Activity Concentrations In Bq/Kg.

Beaches	$^{238}U(^{226}Ra)$	^{232}Th	^{40}K
LEKKI	16.46±2.37	21.40±1.30	182.50±31.70
BAR	15.38±3.00	18.30±2.40	87.70±21.90
ONIRU	31.58±5.20	53.50±5.40	113.20±23.20
ALPHA	20.24±3.31	22.30±2.40	67.80±16.40
ELEKO	27.18±5.02	27.20±3.20	98.20±18.80
COCONUT	11.64±2.53	17.60±3.70	115.40±20.70

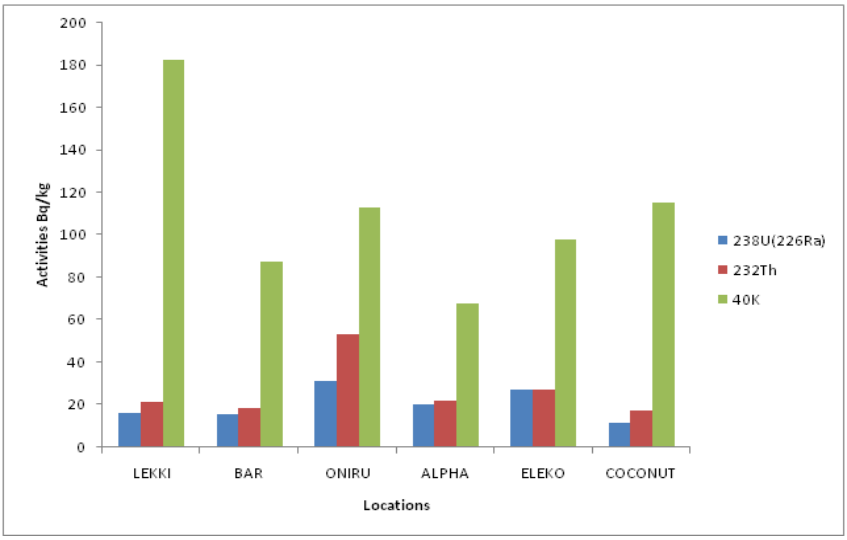

Figure 1

Table 3: Absorbed Dose Rates (Ngy/H), Annual Effective Dose (Msv/Y) and Radium Equivalent Due to Activity Concentrations from the Beach Sands

Beaches	Absorbed Dose Rate (Ngy/H)	Annual Effective Dose Rate (μsv/Y)	Radium Equivalent (Bq/Kg)
LEKKI	29.05	35.63	61.11
BAR	22.49	27.58	48.3
ONIRU	53.77	65.94	116.8
ALPHA	26.32	32.28	57.35
ELEKO	33.83	41.49	73.64
COCONUT	21.58	26.47	45.69

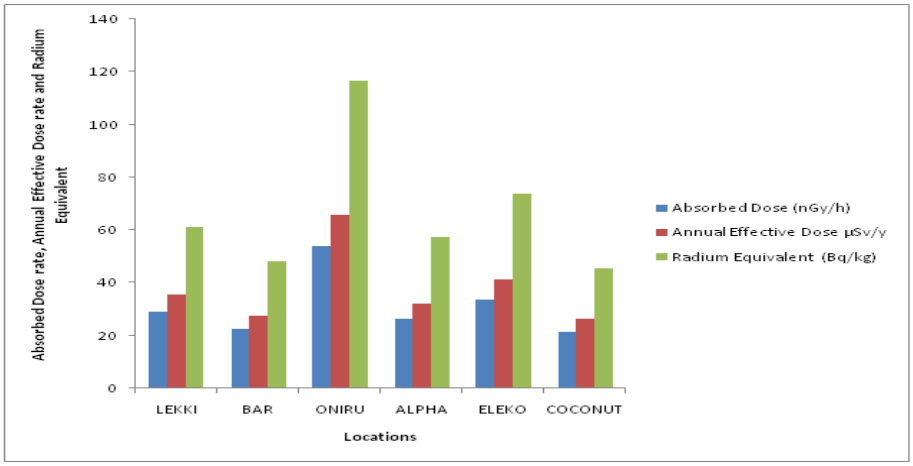

Figure 2

Table 4: Beaches, Calculated Absorbed Dose Rate (Ngy/H), Measured Absorbed Dose Rate (Ngy/H), Annual Effective Dose Rate (µsv/Y), Radium Equivalent (Bq/Kg)

Beaches	Calculated Absorbed Dose Rate (Ngy/H)	Measured Absorbed Dose Rate (Ngy/H)	Annual Effective Dose Rate (µsv/Y)	Radium Equivalent (Bq/Kg)
LEKKI	29.05±3.24	25.05	35.63±3.97	61.11±6.67
BAR	22.49±3.81	23.46	27.58±4.67	48.30±8.12
ONIRU	53.77±6.79	50.71	65.94±8.34	116.80±14.71
ALPHA	26.32±3.71	24.81	32.28±4.55	57.35±8.00
ELEKO	33.83±5.07	32.93	41.49±6.22	73.64±11.04
COCONUT	21.58±4.42	20.85	26.47±5.42	45.69±9.41

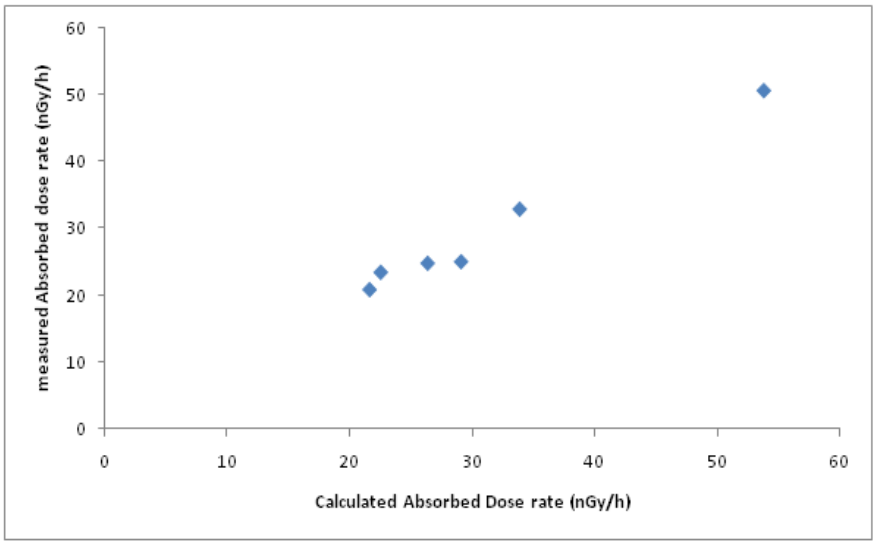

Figure 3

Table 5: Internal and External Hazards

Beaches	H_{1n}	H_{ex}
LEKKI	0.21	0.16
BAR	0.17	0.13
ONIRU	0.40	0.32
ALPHA	0.21	0.15
ELEKO	0.27	0.19
COCONUT	0.15	0.12

CONCLUSIONS

Analysis was done for the six prominent beaches located in Lagos state of Nigeria not only to examine its impact on human health and the environment, but also to explore the potential benefits of the unstoppable sand. The measurements were undertaken for a period of six months while the experimental analysis took place in the laboratory. The results from the studies indicated that Oniru beach had the highest average value of calculated and measured gamma dose rate of 53.77 ± 6.79 and 50.71± 1.0 while Coconut beach recorded lowest value of 21.58 ±4.42 and 20.85 ± 2.9 respectively. The values show that the beaches have normal background adiation. The average radiation levels in the beaches can not pose significant radiological hazard and could safely be use by tourists as holiday resorts. Sand fromthe beaches is recommended for construction and for other purposes.

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