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Research Article

Evaluation of Radiological Hazard Indices of Oniru Beach, Lagos, Nigeria Using Measurements of Natural Radionuclides ^{238}U, ^{232}Th and ^{40}K

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ABSTRACT

This study assesses the radiological risks associated with naturally occurring radionuclides ^{238}U, ^{232}Th, and ^{40}K present in the sands of Oniru Beach, situated in Lagos, Nigeria. These radionuclides, naturally present in geological materials, can pose health hazards when found in elevated concentrations, especially in areas with regular human activity such as recreational beaches. Gamma-ray spectrometry was employed to measure the activity concentrations of ^{40}K, ^{238}U, and ^{232}Th in sand samples collected from multiple points along the beach. The mean activity concentrations recorded were 10.85 Bq·kg^{-1} for ^{238}U, 9.25 Bq·kg^{-1} for ^{232}Th, and 265 Bq·kg^{-1} for ^{40}K. The potential radiological impacts of these concentrations were evaluated to determine their hazard indices. These include the radium equivalent activity (Ra_{eq}), estimated at 44.5 Bq·kg^{-1}, the external hazard index (H_{ex}) of 0.120, and the internal hazard index (H_{in}) of 0.149. The absorbed dose rate (D) of 21.66 nGy·h^{-1}; the annual effective dose equivalent (AEDE) of 0.0266 mSv/y; and the excess lifetime cancer risk (ELCR) estimated at 9.30×10^{-2}. When compared with internationally recognized safety thresholds, such as those set by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), all the calculated indices fall well below recommended limits. This suggests that exposure to sand at Oniru Beach does not present any significant radiological hazard to public health.

Keywords: Radiological hazard indices, Oniru beach, Natural radionuclides, Environmental safety

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Introduction

Naturally occurring radionuclides (such as ^{238}U, ^{232}Th, and ^{40}K), are intrinsic components of the Earth's lithosphere and represent the principal contributors to natural background ionizing radiation. Because of their extremely long half-lives and stable geochemical behavior, these radionuclides remain in environmental media for geological timescales and are routinely detected in rocks, soils, sediments, and aquatic systems. Through their radioactive decay series, they emit ionizing radiation that accounts for a significant proportion of the radiation dose received by humans via both external exposure and internal uptake pathways [1].

Coastal beaches are highly dynamic depositional environments where physical reworking processes can lead to spatial variability and, in some cases, enhancement of natural radionuclide concentrations. Continuous interactions involving wave action, tidal currents, wind transport, erosion, and sediment deposition promote the selective accumulation of heavy mineral fractions within beach sands. Minerals such as monazite, zircon, rutile, and ilmenite are known to host elevated levels of uranium and thorium, and their concentration through natural sorting mechanisms can result in localized zones of enhanced natural radioactivity along coastlines [2, 3].

Investigations conducted in different coastal regions worldwide, including several studies along the Nigerian shoreline, have reported a wide range of activity concentrations for ^{238}U, ^{232}Th, and ^{40}K in beach sediments. These variations are primarily controlled by regional geology, sediment source materials, and the intensity of coastal processes [4]. Human exposure may occur through direct irradiation from contaminated sands as well as indirectly through inhalation or ingestion of re-suspended radioactive particles during recreational or occupational activities. Although the associated dose levels are often within internationally recommended limits, prolonged low-level exposure may contribute to an increased probability of stochastic health outcomes, particularly cancer, especially for individuals with frequent or long-term beach contact [5, 6].

Oniru Beach, located along the Atlantic coast of Lagos State, Nigeria, is a major recreational site characterized by intense and continuous human use. Despite its popularity and socio-economic significance, systematic information on the radiological characteristics of its beach sands remains scarce. This lack of baseline data limits effective radiological monitoring and risk evaluation. Consequently, assessing the natural radioactivity levels of beach sediments in this area is essential for understanding potential exposure scenarios, ensuring adherence to international radiation protection guidelines, and safeguarding public health.

In view of this, the present study applies gamma-ray spectrometric techniques to quantify the activity concentrations of ^{238}U, ^{232}Th, and ^{40}K in sand samples collected from Oniru Beach. The obtained activity data are further used to estimate standard radiological hazard indices, including radium equivalent activity (Ra_{eq}), external and internal hazard indices (H_{ex} and H_{in}), absorbed dose rate (D), annual effective dose equivalent (AEDE), and excess lifetime cancer risk (ELCR). The findings of this study provide baseline radiological information for the study area and contribute to the broader understanding of natural radiation exposure in coastal environments.

2. Materials and Methods

2.1 Study Area

Oniru Beach is situated along the Atlantic coastline of Lagos, Nigeria. It is geographically located between latitude 6.42236 and 6.47843 and longitude 3.43792 and 3.74074 with an elevation range of 1 to 4 m (Fig.1). The beach is characterized by sandy sediments, influenced by both marine and terrestrial sources. Human activities, including tourism and nearby urban development, may influence the distribution and concentration of natural radionuclides in the area.

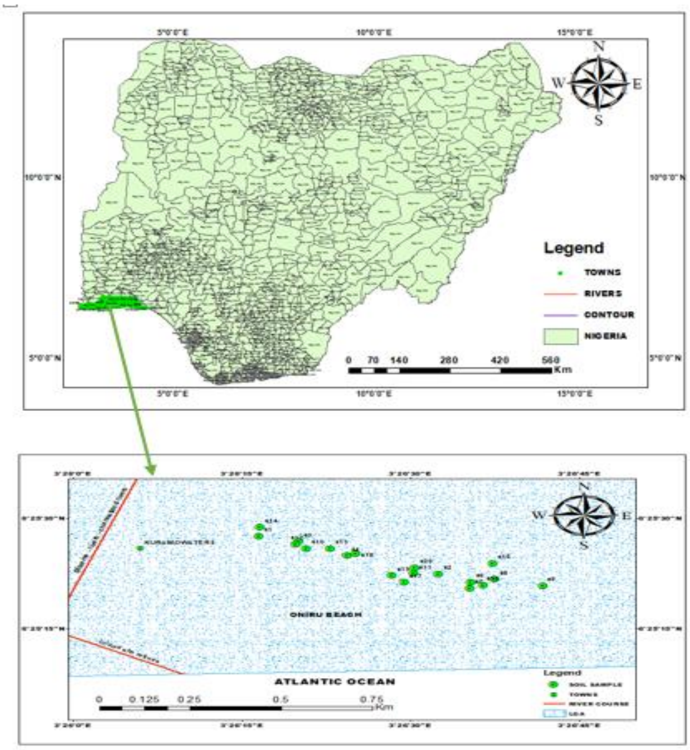

Fig.1 *Spatial distribution of soil sample points in the study area*

2.2. Sample Collection and Preparation

20 sand samples were randomly collected from multiple locations at a depth of 0-10 cm, and distance of 10 m from one point to the other for the purpose of obtaining a representative assessment. The collected samples were packed inside a well-labelled polythene bag and transported to the laboratory.

At the laboratory, the samples were air-dried for 72 hours, oven-dried at a temperature of 110^0C for 18 hours to remove moisture completely, and sieved with 2 mm mesh size to homogenise the samples and obtain uniform particle size (Fig. 2- Plate 1). A 300 g of the prepared samples were sealed in appropriately labelled 500 ml plastic container for 30 days so that equilibrium conditions can develop between ^{226}Ra and its radioactive progeny.

Fig.2 *Plate 1, sieving the soil samples*

2.3. Gamma-Ray Spectrometry

Gamma-ray spectrometric measurements of the soil samples were carried out using a well-shielded 3″ × 3″ NaI(Tl) scintillation detector (Fig.3- Plate 2), coupled to a Quantum MCA2100R multichannel analyzer. Each sample was counted for 36.000 s (10 h), and background spectra obtained from an empty container of identical geometry and counting time were subtracted to correct for ambient radiation [7].

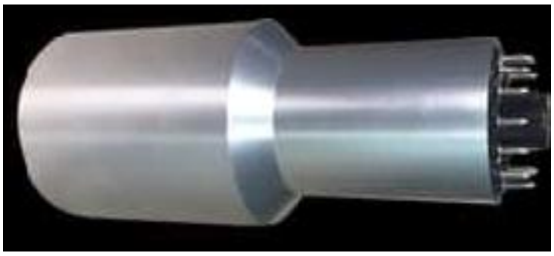

Fig.3. *Plate 2, 3 inch x3 inch NaI(Tl) scintillation detector*

Detector efficiency was calibrated with a multi-nuclide reference source traceable to the Analytical Quality Control Service (AQCS, USA), positioned in the same geometry as the soil samples. Energy calibration was achieved using the characteristic photopeaks of the reference standard, yielding a linear relationship between channel number and gamma-ray energy [7].

The activity concentrations of naturally occurring radionuclides were evaluated using their characteristic gamma emissions. The activity of ^{40}K was determined from its 1460 keV photopeak, while the ^{238}U series, assuming secular equilibrium, was quantified via the 1764.5 keV gamma line of ^{214}Bi. The activity concentration of the ^{232}Th series was obtained from the 2614 keV gamma emission of ^{208}Tl. Where applicable, the presence of anthropogenic ^{137}Cs was assessed using its 661.6 keV gamma line [7].

The 3″ × 3″ NaI(Tl) detector remains widely adopted for environmental gamma-ray spectrometry of primordial radionuclides because it provides a favourable compromise between detection efficiency up to about 3 MeV and an energy resolution of approximately 7-8% FWHM at 662 keV. Collectively, these measurement and calibration procedures ensured robust and reliable determination of radionuclide activity concentrations in the soil samples [7].

2.4. Radiological Hazard Indices Evaluation

The following indices were calculated using the respective relations.

Radium Equivalent Activity (Ra_{eq}):

$$Ra_{eq} = A_CU + (1.43\times A_CTh) + (0.077\times A_CK) \text{ in Ref.[8]} \quad (1)$$

External Hazard Index (H_{ex}):

$$H_{ex} = (A_CU/370) + (A_CTh/259) + (A_CK/4810) \text{ in Ref.[8]} \quad (2)$$

Internal Hazard Index (H_{in}):

$$H_{in} = (A_CU/185) + (A_CTh/259) + (A_CK/4810) \text{ in Ref.[9]-} \quad (3)$$

Absorbed Dose Rate (D);

$$D(nGy/h)=0.462\times A_CU+0.604\times A_CTh+0.0417\times A_CK \text{ in Ref.[10]} \quad (4)$$

Annual Effective Dose Equivalent (AEDE);

$$AEDE\ (mSv/y) = D\times 8760\times 0.2\times 0.7\times 10^{-6} \text{ in Ref[11]} \quad (5)$$

Excess Lifetime Cancer Risk (ELCR);

$$ELCR = AEDE \times \text{Duration of life (70 years)} \times \text{Risk factor } (0.05\ Sv^{-1}) \text{ in Ref[12]} \quad (6)$$

Where A_CU, A_CTh, and A_CK are the activity concentrations ($Bq\cdot kg^{-1}$) of ^{238}U, ^{232}Th, and ^{40}K, respectively, are given in [13].

2.4.1 Uncertainty Analysis of Radiological Hazard Indices

The errors associated with radiological hazard indices were determined using the conventional law of propagation of uncertainty. This method assumes that the measured activity concentrations of ^{40}K, ^{238}U, and ^{232}Th are statistically independent and that their associated uncertainties obey a normal (Gaussian) distribution.

$$\text{For } y = f(x_1, x_2, x_3, \ldots) \quad (7)$$

$$\sigma_y=\sqrt{[(\partial y/\partial x_1\cdot\sigma x_1)^2+(\partial y/\partial x_2\cdot\sigma x_2)^2+(\partial y/\partial x_3\cdot\sigma x_3)^2+..]} \quad (8)$$

Where; σ_y is the uncertainty

Radium Equivalent Activity (Ra_{eq});

$$\sigma Ra_{eq} = \sqrt{[\sigma U^2 + (1.43\ \sigma Th)^2 + (0.077\ \sigma K)^2]} \quad (9)$$

External Hazard Index (H_{ex});

$$\sigma H_{ex} = \sigma Ra_{eq} / 370 \quad (10)$$

Internal Hazard Index (H_{in});

$$\sigma H_{in} = \sqrt{[(\sigma U/185)^2 + (\sigma Th/259)^2 + (\sigma K/4810)^2]} \quad (11)$$

Absorbed Gamma Dose Rate (DR);

$$\sigma DR=\sqrt{[(0.462\sigma U)^2+(0.604\sigma Th)^2+(0.0417\sigma K)^2]} \quad (12)$$

Annual Effective Dose Equivalent (AEDE);

$$\sigma AEDE = 0.001226 \times \sigma DR \quad (13)$$

Excess Lifetime Cancer Risk (ELCR);

$$\sigma ELCR = \sigma AEDE \times DL \times RF \quad (14)$$

where DL = 70 years and RF = 0.05 Sv^{-1}

3. Results and Discussion

The results (Fig.4), showed that ^{40}K has the highest activity concentration across all soil samples, markedly exceeding those of ^{238}U and ^{232}Th. The measured ^{40}K values lie roughly between 210 and 300 $Bq \cdot kg^{-1}$, reflecting the natural abundance of potassium-containing minerals in the soils.

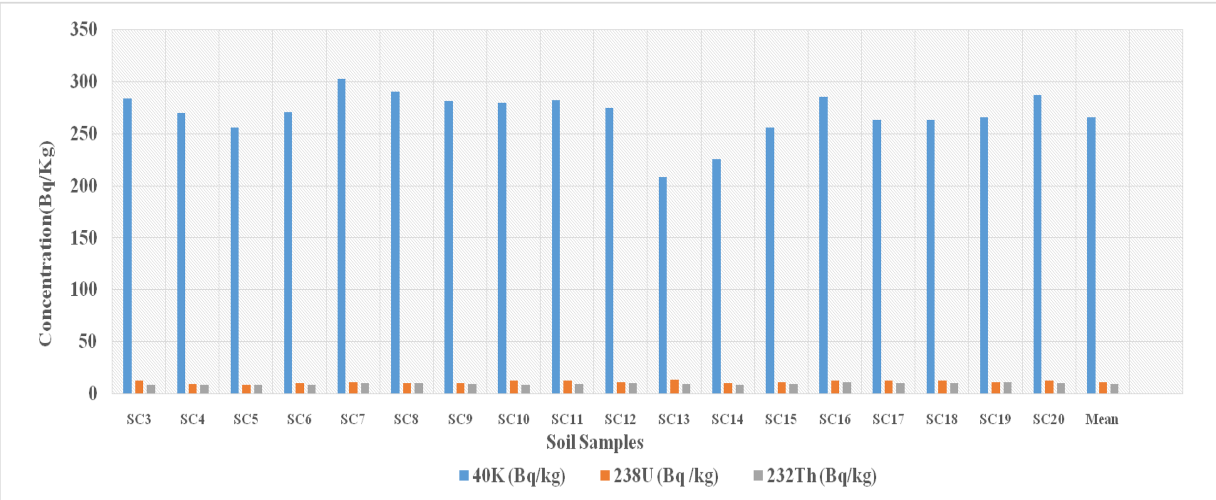

Fig.4 *Radioactive isotope concentration by sample point*

By comparison, ^{238}U shows lower activity levels, generally within 8-15 $Bq \cdot kg^{-1}$, while ^{232}Th presents the lowest concentrations, ranging from about 5 to 10 $Bq \cdot kg^{-1}$ (Table 1). The limited variation observed among the samples suggests a relatively homogeneous geological composition. In general, the average activity concentrations decrease in the order $^{40}K > ^{238}U > ^{232}Th$, and all values are consistent with natural background radiation levels, indicating the absence of significant radiological enrichment in the area.

3.1 Radiological Hazard Indices with Propagated Uncertainties

The estimated errors associated with radiological hazard indices Table 3; radium equivalent activity (Ra_{eq}), external hazard index (H_{ex}), internal hazard index (H_{in}), absorbed gamma dose rate (DR), annual effective dose equivalent (AEDE), and excess lifetime cancer risk (ELCR) were determined from measured activity concentrations of ^{40}K, ^{238}U, and ^{232}Th, using first-order Gaussian error propagation, (Equations 6-13). The results of propagated errors revealed that the dominant contributors to the overall uncertainty budget are the activity concentrations of ^{238}U and ^{232}Th, resulting from their relatively large dose conversion coefficients.

However, despite these uncertainties, all values of Ra_{eq} remain significantly below the recommended safety limit of 370 Bq·kg⁻¹, while H_{ex} and H_{in} are well below unity for all samples, as given in Table 2. The AEDE values are substantially lower than the global average outdoor exposure of 0.48 mSv·y⁻¹, and the corresponding ELCR values fall within internationally acceptable limits, indicating no significant radiological health risk to the public.

Table 1. Radioactivity concentration of natural radionuclides of Oniru Beach Sands

Sample ID	^{40}K (Bq·kg^{-1})	^{238}U (Bq·kg^{-1})	^{232}Th (Bq·kg^{-1})
SC1	223.16 ± 0.01	9 ± 0.11	9 ± 0.01
SC2	240.09 ± 0.16	10 ± 0.20	10 ± 1.03
SC3	283.10 ± 1.03	12 ± 2.01	8 ± 1.10
SC4	269.32 ± 1.10	9 ± 1.01	8 ± 0.10
SC5	255.20 ± 2.03	8 ± 1.03	8 ± 1.10
SC6	270.32 ± 1.41	10 ± 1.05	8 ± 1.02
SC7	302.40 ± 1.20	11 ± 2.10	10 ± 1.02
SC8	290.31 ± 2.15	10 ± 2.30	10 ± 1.03
SC9	281.14 ± 2.86	10 ± 4.20	9 ± 2.10
SC10	279.48 ± 3.20	12 ± 2.20	8 ± 2.34
SC11	282.13 ± 2.01	12 ± 1.01	9 ± 1.12
SC12	274.12 ± 1.10	11 ± 2.20	10 ± 1.13
SC13	208.23 ± 4.17	13 ± 2.25	9 ± 2.16
SC14	225.10 ± 3.10	10 ± 1.21	8 ± 3.20
SC15	255.12 ± 2.03	11 ± 1.51	9 ± 1.18
SC16	285.02 ± 2.21	12 ± 2.03	11 ± 1.22
SC17	263.10 ± 2.03	12 ± 2.03	10 ± 1.08
SC18	263.03 ± 2.01	12 ± 2.03	10 ± 1.01
SC19	265.20 ± 1.03	11 ± 2.03	11 ± 1.03
SC20	287.12 ± 1.02	12 ± 2.03	10 ± 1.02
Mean	**265.13** ± 1.80	**10.85** ±1.73	**9.25** ±1.25

Table 2. Radiological Hazard Indices Assessment of Oniru Beach Sands

Sample ID	Ra_{eq}	H_{ex}	H_{in}	DR (nGy/h)	AEDE(mSv/y)	ELCR x10^{-5}
SC1	39.05	0.11	0.13	18.97	0.02	8.17
SC2	42.79	0.12	0.14	20.74	0.03	8.93
SC3	45.24	0.12	0.15	22.27	0.03	9.59
SC4	41.18	0.11	0.14	20.30	0.02	8.74
SC5	39.09	0.11	0.13	19.25	0.02	8.29
SC6	42.25	0.11	0.14	20.81	0.03	8.96
SC7	48.58	0.13	0.16	23.82	0.03	10.26
SC8	46.65	0.13	0.15	22.85	0.03	9.84
SC9	44.52	0.12	0.15	21.86	0.03	9.41
SC10	44.96	0.12	0.15	22.11	0.03	9.52
SC11	46.59	0.13	0.16	22.83	0.03	9.83
SC12	46.41	0.13	0.16	22.64	0.03	9.74
SC13	41.90	0.11	0.15	20.19	0.02	8.69
SC14	38.77	0.10	0.13	18.91	0.02	8.14
SC15	43.51	0.12	0.15	21.23	0.03	9.14
SC16	49.68	0.13	0.17	24.16	0.03	10.40
SC17	46.56	0.13	0.16	22.63	0.03	9.74
SC18	46.55	0.13	0.16	22.63	0.03	9.75
SC19	47.15	0.13	0.16	22.86	0.03	9.84
SC20	48.41	0.13	0.16	23.64	0.03	10.18

3.2 Statistical Analysis of Radiological Hazard Indices of Oniru Beach Sand

All indices calculated at Oniru Beach are well below the international safety limits, indicating no significant radiological hazard to public health from beach sands exposure; this is attributable to the geological setting of Oniru Beach which lies within the coastal sedimentary terrain of Southwestern Nigeria [4].

The region is free from significant tectonic deformation and radioactive mineralization typical of igneous terrains such as granitic or metamorphic rocks. Thus, the sands deposited along the coast originate primarily from marine, fluvial, and deltaic processes, with very limited contributions from high-radioactivity source rocks [14]. Therefore, geologic composition limits the natural enrichment of radionuclides in the beach sands, resulting in relatively low activity concentrations of 10.85 Bq·kg^{-1} for ^{238}U, 9.25 Bq·kg^{-1} for ^{232}Th, and (265.1 Bq·kg^{-1} for ^{40}K, on the average.

Additionally, the dominant material at Oniru Beach is fine to medium-grained sand, characterized by low clay, and organic contents, high permeability and porosity with weak radionuclide retention potential. These properties play a significant role in determining radiological behaviour with sandy soils lacking in the binding quality needed for heavy radionuclides like uranium and thorium, reducing accumulation [15]. The low sorption and retention capacity due to limited clay minerals and humic substances results in radionuclides being easily leached or dispersed [16,17]. Dynamic coastal processes such as tides, wave action, and erosion are contributory factors to continuous sediment mixing, which dilutes radionuclide concentrations and prevents long-term accumulation [18].

The radiological assessment of beach sand samples from Oniru Beach, Lagos, conducted to evaluate potential health risks associated with natural radionuclides; ^{40}K, ^{238}U and ^{232}Th yielded safe threshold status: The Radium Equivalent Activity (Ra_{eq}) which combines the effects of all three radionuclides, averaged 44.5 Bq·kg^{-1}, far below the recommended maximum of 370 Bq·kg^{-1}**, t**he Annual Effective Dose Equivalent (AEDE) is 0.0266 mSv/y, which is well under the UNSCEAR public exposure limit of 0.07 mSv/y for outdoor environments and the Excess Life time Cancer Risk (ELCR) remaining within safe limits, averaging 0.093%, compared to the global reference risk level of 0.29%. All these are essentially attributable to the geological background and soil characteristics of the Oniru Beach site as enumerated above. All radiological hazard indices fall well below international limits set by UNSCEAR and ICRP. These findings confirm that Oniru Beach sands present no significant radiological hazard to public health, which by implication is safe for recreational and residential use and support sustainable tourism and development with minimal health risks. Given the favorable geological and soil conditions, the results can serve as a baseline for future environmental monitoring and policy planning in coastal zones.

The comparison shows that the radiological parameters recorded at Oniru Beach are significantly lower than those from other regional beaches such as Bar Beach, Lekki, and Suntan Beach, as well as the global averages recommended by [1]. In all cases, the measured radium equivalent activity (Raeq), hazard indices (Hex, Hin), absorbed dose rate, and effective dose remain well below international limits. While beaches like Suntan and Bar. Beach show moderately higher activity levels likely due to localised geological factors, denser human activities, or sediment transport, Oniru Beach's low radionuclide content is reflective of its relatively cleaner sediment source and younger sedimentary geology (Benin Formation) [4]. The low ELCR value also suggests negligible lifetime cancer risk from exposure to natural background radiation in the area.

Table 3. Radiological hazard indices with propagated uncertainties

Sample	Ra_{eq} ($Bqkg^{-1}$)	H_{ex}	H_{in}	DR ($nGy\ h^{-1}$)	AEDE ($mSv\ y^{-1}$)	ELCR $\times 10^{-5}$
SC1	39.05 ± 0.11	0.106 ± 0.0003	0.130 ± 0.0006	18.90 ± 0.05	0.0232 ± 0.0001	8.12 ± 0.02
SC2	42.79 ± 1.49	0.116 ± 0.0040	0.143 ± 0.0041	20.67 ± 0.63	0.0253 ± 0.0008	8.86 ± 0.28
SC3	45.24 ± 2.55	0.122 ± 0.0069	0.155 ± 0.0117	22.18 ± 1.14	0.0272 ± 0.0014	9.51 ± 0.50
SC4	41.18 ± 1.02	0.111 ± 0.0028	0.136 ± 0.0055	20.22 ± 0.47	0.0248 ± 0.0006	8.68 ± 0.21
SC5	39.09 ± 1.89	0.106 ± 0.0051	0.127 ± 0.0070	19.17 ± 0.82	0.0235 ± 0.0010	8.24 ± 0.36
SC6	42.25 ± 1.80	0.114 ± 0.0049	0.141 ± 0.0069	20.72 ± 0.79	0.0254 ± 0.0010	8.89 ± 0.35
SC7	48.58 ± 2.56	0.131 ± 0.0069	0.161 ± 0.0120	23.73 ± 1.15	0.0291 ± 0.0014	10.02 ± 0.50
SC8	46.65 ± 2.74	0.126 ± 0.0074	0.153 ± 0.0131	22.77 ± 1.23	0.0279 ± 0.0015	9.77 ± 0.53
SC9	44.52 ± 5.17	0.120 ± 0.0140	0.147 ± 0.0241	21.78 ± 2.32	0.0267 ± 0.0028	9.34 ± 0.99
SC10	44.96 ± 4.01	0.122 ± 0.0108	0.154 ± 0.0149	22.03 ± 1.75	0.0270 ± 0.0021	9.47 ± 0.73
SC11	46.59 ± 1.90	0.126 ± 0.0051	0.154 ± 0.0070	22.52 ± 0.79	0.0276 ± 0.0010	9.66 ± 0.35
SC12	46.41 ± 2.73	0.125 ± 0.0074	0.153 ± 0.0130	22.33 ± 1.23	0.0274 ± 0.0015	9.59 ± 0.53
SC13	41.90 ± 3.83	0.113 ± 0.0104	0.144 ± 0.0190	19.97 ± 1.68	0.0245 ± 0.0021	8.57 ± 0.73
SC14	38.77 ± 4.74	0.105 ± 0.0128	0.130 ± 0.0204	18.52 ± 1.99	0.0227 ± 0.0024	7.95 ± 0.85
SC15	43.51 ± 2.27	0.118 ± 0.0061	0.148 ± 0.0100	21.58 ± 1.02	0.0265 ± 0.0013	9.28 ± 0.45
SC16	48.16 ± 2.46	0.130 ± 0.0067	0.162 ± 0.0116	23.87 ± 1.10	0.0293 ± 0.0013	10.03 ± 0.50
SC17	46.27 ± 2.33	0.125 ± 0.0063	0.154 ± 0.0109	22.33 ± 1.07	0.0274 ± 0.0013	9.59 ± 0.45
SC18	46.26 ± 2.30	0.125 ± 0.0062	0.154 ± 0.0107	22.32 ± 1.04	0.0274 ± 0.0013	9.59 ± 0.45
SC19	47.26 ± 2.21	0.128 ± 0.0060	0.159 ± 0.0104	23.12 ± 1.00	0.0283 ± 0.0012	9.90 ± 0.43
SC20	47.09 ± 2.60	0.127 ± 0.0070	0.159 ± 0.0122	23.36 ± 1.15	0.0287 ± 0.0014	10.00 ± 0.50

Table 4. Summary of results of the six key radiological hazard indices computed from the activity concentrations of natural radionuclides (^{40}K, ^{238}U, ^{232}Th) from Oniru Beach sands

Hazard Index	**Mean**	**Min**	**Max**	**Std Dev**	**Safety Limit**
K-40 (Bq kg^{-1})	265.13	208.23	302.40	24.64	—
U-238 (Bq kg^{-1})	10.85	8.00	13.00	1.31	—
Th-232 (Bq kg^{-1})	9.25	8.00	11.00	1.02	—
Radium Equivalent (Ra_{eq})	44.49	38.77	49.68	3.29	< 370 Bq kg^{-1}
External Hazard Index (H_{ex})	0.120	0.105	0.134	0.0089	< 1
Internal Hazard Index (H_{in})	0.149	0.127	0.167	0.0115	< 1
Absorbed Dose Rate (nGy/h)	21.66	18.84	24.07	1.60	~55 nGy/h (global avg)
Annual Effective Dose (AEDE, mSv/y)	0.0266	0.0231	0.0295	0.0020	< 0.07 mSv/y
Excess Lifetime Cancer Risk (ELCR)	9.30×10^{-2}	8.09×10^{-2}	1.03×10^{-1}	6.86×10^{-3}	< 0.29 (ICRP limit)

4. Conclusion

The low levels of natural radionuclide concentrations and radiological hazard indices observed at Oniru Beach can be directly linked to the site's young sedimentary geology and sandy, low-retention soil type. The dynamic nature of coastal processes and the lack of radioactive mineral inputs further minimize radiological risks.

Furthermore, the findings from Oniru Beach are consistent with broader trends in southwestern Nigeria, where beach sands typically exhibit low to moderate natural radioactivity**,** primarily due to the sedimentary origin of the coastal plain. However, Oniru Beach stands out as one of the safest, radiologically, among the studied beaches, making it suitable for recreational and environmental use; consequently, Oniru Beach is considered, radiologically, safe for both environmental and human activities with no immediate or long-term health risks to humans patronizing the facility.

Conflict of Interest

All the authors declare no conflict of interest.

Ethical Review and Approval

We, the authors, confirm that this manuscript, submitted for consideration and possible publication in this journal, does not require ethics committee review or approval

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