Available online at www.jobpcr.com

Journal of Biological Pharmaceutical And Chemical Research , 2014,1(1):123-131

(http://www.jobpcr.com/arhcive.php)

Radiation hazard index and excess lifetime cancer risk due to natural radioactivity in environmental matrix waste dumpsite, Rivers state.

AVWIRI, G.O., NTE F.U. , OLANREWAJU, A. I.

ABSTRACT

Evaluation of the radionuclides (^{238}U, ^{232}Th and ^{40}K) content to understand the radiation hazards from the waste dumpsite areas to mankind. Natural radioactivity analysis has been carried out for the samples collected from different points of Eliozu reclaimed dumpsite of rivers state, Nigeria. The determined activity concentrations of some sample sites fall within the typical world values with variation in some showing extreme values. To assess the radiological hazard of soils and water samples, the radiological hazard indices such as absorbed dose rate, annual effective dose equivalent (outdoor and indoor) (AEDE), hazard indices (H_{ex} and H_{in}), activity utilization index (I) and excess life time cancer risk (ELCR) are calculated. The radiological hazard indices are below the internationally recommended values. The present values of indoor and outdoor AEDE is lower than 70 Sv/y and 450 Sv/y for outdoor and indoor in the world average values (Orgun et al., 2007). Average ELCR for all samples is less than the world average (0.29×10^{-3}) (Taskin et al., 2009). This indicates that the Eliozu's soils and waters are safe for construction purpose and for utilization.

Keywords: Absorbed dose rate, Excess life cancer risk, Annual effective dose equivalent, Hazard indices, activity utilization

INTRODUCTION

The disposal of the waste without adequate management, particularly the radioactive contaminants expose the populace to radiation hazard. Waste disposal by landfill has led to the pollution of environmental resource such as water, land and air thus, landfills are liable recipient of any such failure in containment of radioactive materials (Farai et al., 2007). Contamination of land and water can occur from deposition of waste materials originally introduced into the atmosphere, from discharge directly into surface or subsurface waters, from wastes placed in or on the ground. Wastes generated by human activities ranges from relatively innocuous substances to toxic substances and high-level (radioactive) waste contain elements of harmful substances whose origin and risk to human and environmental health can be of great concern.

The dumping of large amount of waste materials in sites without adequate soil protection measures results in soil surface and groundwater pollution (Eikelboom et. al., 2001)

Atmospheric pollutants eventually deposit on soils or surface waters involve transport by water by a sequence of processes, including surface runoff and leaching into soil-water that eventually seeps to streams.

Groundwater or erosion surface water may eventually mobilizes the land contaminant which can be passed to subsurface aquifers, soils, and the atmosphere. Natural environmental radioactivity due to gamma radiation depends on the geological and geographical conditions, and found in various quantities in soils around the world (UNSCEAR, 2000).

One of the main determinants of the natural background radiation is the soil radionuclide activity concentration; disintegrated rocks through natural process allow radionuclides to escape to soil by rain and flows. In addition to the natural sources; soil radioactivity is also affected by anthropogenic activities.

There are radioactive isotopes in our environments, air, water and ground (Eisenbud and Gesell, 1997; Henriksen and Maillie, 2003) measurement is only reliable source to accurately reflect people's true exposure. Over-emphasizing the effect caused by radon decays with a series of solid, short-lived radioisotopes that are collectively referred to as radon daughters or radon progeny. Isotopes of such can emit alpha particles of high energy and high mass particles consisting of two protons and two neutrons. When these emissions take place within the lung as inhaled radon progeny decay the genetic material of the cells lining the airways may be damaged and lung cancer may result. (NRC, 1980)

Naturally occurring radioactive materials are found in both groundwater and surface water. At high levels, when ionizing radiation strikes a living organism's cells, it may mutate the organism's cell. If radiation affects a significant number of cells, the organism may eventually develop cancer among other liable diseases.

In order to assess any possible radiological hazard to mankind due to the waste dump of the site this is suggested to have allowed easy passage root of constituent radionuclides. Hence, the objective of this study is to evaluate radiation hazard index and excess lifetime cancer risk due to the natural radioactivity in soil and water around reclaimed waste dumpsite.

MATERIALS AND METHOD

STUDY AREA

Present study is located along Eliozu Rukpoku road and lies between Latitudes $4^0$50' to $4^0$53'N and Longitude $7^0$00' to $7^0$02'E within Port Harcourt Metropolis in Obio/ Akpor Local Government Area of Rivers State in Nigeria. The survey area is accessible through networks of tarred roads. The site is traversed by a set of high-voltage power transmission line owned by the Power Holding Company of Nigeria (PHCN) and two swamps, one adjacent to and the other opposite the landfill. There are residential houses nearby but they are not at obvious serious threat from landfill radiations since they are quite distant from the landfill. The site has been closed by the government and sealed by security agency for reclamation activities and thus limit the activities of scavengers and do not allow them to construct make shift structures.

			Soils (Bq/kg)					Water (Bq/l)		
S/N	**GPS Location**	**Samples**	**K-40**	**U-238**	**Th-232**	**GPS Location**	**Samples**	**K-40**	**U-238**	**Th-232**
1	N04^{0}53.086' E007^{0}00.	**A1**	570.08 ± 87.56	20.52 ± 5.22	18.95 ± 9.90	N04^{0}53.060' E007^{0}00.785'	**W1**	16.40 ± 7.28	8.24 ± 2.82	5.87 ± 1.98

	797’									
2	N04^{0}53.105’ E007^{0}00.800’	**A2**	105.57 ± 24.87	18.94 ± 8.43	16.62 ± 6.74	N04^{0}53.969’ E007^{0}00.806’	**W2**	26.74 ± 7.70	7.48 ± 3.32	7.44 ± 2.22
3	N04^{0}53.160’ E007^{0}00.794’	**A3**	404.95 ± 99.76	34.81 ± 13.58	19.33 ± 6.46	N04^{0}53.084’ E007^{0}00.693’	**W3**	24.98 ± 9.81	9.32 ± 2.25	8.32 ± 2.45
4	N04^{0}53.182’ E007^{0}00.794’	**A4**	140.49 ± 35.76	23.87 ± 9.73	17.84 ± 6.47	N04^{0}53.270’ E007^{0}00.781’	**W4**	19.84 ± 6.98	7.89 ± 3.04	7.89 ± 2.14
5	N04^{0}53.201’ E007^{0}00.801’	**A5**	254.55 ± 79.45	38.28 ± 11.40	29.54 ± 11.54	N04^{0}53.179’ E007^{0}00.796’	**W5**	23.51 ± 9.73	8.04 ± 2.11	6.78 ± 2.34
6	N04^{0}53.230’ E007^{0}00.831’	**A6**	256.22 ± 68.64	26.54 ± 9.65	22.46 ± 8.69	N04^{0}53.139’ E007^{0}00.797’	**W6**	32.08 ± 8.17	9.06 ± 3.21	8.29 ± 3.09
7	N04^{0}53.085’ E007^{0}00.893’	**A7**	527.91 ± 89.35	35.91 ± 11.35	19.41 ± 9.98	N04^{0}53.112’ E007^{0}00.802’	**W7**	16.12 ± 7.21	9.41 ± 2.65	7.89 ± 2.54
8	N04^{0}53.986’ E007^{0}00.799’	**A8**	545.13 ± 87.49	26.41 ± 11.14	18.63 ± 7.84	N04^{0}53.230’ E007^{0}00.831’	**W8**	27.16 ± 9.02	6.94 ± 3.53	5.20 ± 1.99
9	N04^{0}53.034’ E007^{0}00.783’	**A9**	323.64 ± 75.86	29.36 ± 9.32	13.43 ± 7.32	N04^{0}53.316’ E007^{0}00.822’	**W9**	21.67 ± 7.43	5.99 ± 2.10	4.76 ± 2.08
10	N04^{0}53.294’ E007^{0}00.793’	**A10**	132.23 ± 18.65	19.44 ± 9.89	16.52 ± 6.46	N04^{0}53.347’ E007^{0}00.794’	**W10**	39.15 ± 9.98	6.85 ± 1.83	7.34 ± 2.87
	Average Values		326 ± 66.74	27.41 ± 9.97	19.27 ± 8.14		**Average Values**	24.77± 8.33	7.92±2.69	6.96±2.37

SOIL

S/N	D(nG/hr)	AGED(μSv/yr)	Ra (Bq/kg)	Hazard Indices		I_{yr}	AEDE		ELCR x 10^{-3}
				H_{ex}	H_{in}		outdoor	Indoor	
1	45.25 ± 12.45	321.62	91.52	0.247	0.303	0.71	55.49	221.98	0.1942
2	23.53 ± 9.11	161.09	50.84	0.137	0.188	0.32	28.86	115.43	0.1010
3	44.68 ± 14.28	315.52	93.63	0.253	0.347	0.73	54.80	219.18	0.1924
4	27.92 ± 9.95	192.44	60.20	0.163	0.227	1.28	34.24	136.96	0.1198
5	46.60 ± 15.84	321.69	100.12	0.270	0.374	0.68	57.15	228.60	0.2000
6	36.97 ± 12.76	256.34	78.39	0.212	0.283	0.52	45.34	181.36	0.1587
7	50.39 ± 15.21	357.86	104.32	0.282	0.379	0.83	61.80	247.19	0.2163
8	46.52 ± 13.63	330.65	95.03	0.256	0.328	0.72	57.05	228.21	0.1997
9	35.05 ± 12.02	248.48	73.48	0.198	0.278	0.61	42.99	171.94	0.1504
10	24.80 ± 9.29	170.64	53.24	0.144	0.196	0.35	30.41	121.66	0.1065
MEAN	38.17 ± 12.45	267.63	80.08	0.216	0.290	0.58	46.81	187.25	0.1638

WATER

S/N	D(nG/hr)	AGED(μSv/yr)	Ra (Bq/l)	Hazard Indices		I_{yr}	AEDE		ELCR x 10^{-3}
				H_{ex}	H_{in}		outdoor	Indoor	
1	7.80 ± 2.82	55.148	17.890	0.0484	0.0709	0.12	9.57	38.26	0.0334
2	9.24 ± 3.21	62.609	20.180	0.0546	0.0750	0.12	11.33	45.33	0.0397
3	10.54 ± 2.99	71.420	23.140	0.0622	0.0372	0.14	12.93	51.71	0.0452
4	9.43 ± 3.01	63.590	20.698	0.0551	0.0767	0.12	11.57	46.26	0.0405
5	8.91 ± 2.86	60.566	19.550	0.0529	0.0744	0.12	10.93	43.71	0.0382
6	10.71 ± 3.76	72.721	23.380	0.0627	0.0877	0.14	13.14	52.54	0.0456
7	9.92 ± 3.12	67.119	21.930	0.0584	0.0843	0.14	12.17	48.66	0.0426
8	7.55 ± 3.21	51.709	16.470	0.0447	0.0632	0.11	9.26	37.04	0.0324
9	6.62 ± 2.59	45.210	14.467	0.0385	0.0549	0.09	8.12	32.48	0.0284
10	9.68 ± 3.10	64.141	20.365	0.0551	0.0731	0.12	11.87	47.49	0.0416
MEAN	9.03 ± 3.07	61.423	19.807	0.0532	0.0697	0.12	11.07	44.30	0.0388

Sample Collection and Preparation: The present study area covers a total length of 10 Km, from different locations was selected. Location of sampling site with their latitude and longitude are given in Table 1. Each location is separated by nearly equal distance of 1 Km approximately. All soil samples were collected at 0-10 cm depth during the winter season (October-November 2010). Each sample has a weight of 2kg approximately. The collected samples were dried at room temperature in open air for two days and stored in black polythene bags. The samples were dried in an oven 60°C till the constant dry weight was obtained, crushed and homogenized. The homogenized samples were packed in a 250 ml plastic container to its full volume with uniform mass. The water samples were acidified with 11M of HCL at the rate of 10ml per litre of sample immediately after collection to avoid adsorption of radionuclide on the walls of the containers (IAEA, 1989).

All the storing containers were previously washed with dilute sulphuric acid (H_2S0_4) and dried to avoid contamination, filled with about 1litre of water each.

These containers shielded hermetically and also shielded externally to ensure that all daughter products of uranium and thorium, in particular, radon isotope formed, do not escape.

A time of four weeks was allowed after packing to attain secular equilibrium between Ra-226 and its short-lived daughter products. The net weight of the sample was determined before counting.

Radioactivity measurements:

Each sample was then counted using a gamma ray spectrometer with NaI(TI)detector coupled with an amplifier, which amplifies the incoming signals and integrates them to volts (0-10volts). The detector was shielded by thick massive lead on all sides to reduce background of the system. The detector have an efficiency of 18-20%. The detector has resolution of specified for detectors as the full width (in KeV) at half maximum (FWHM) of the full energy peak of the 1.33MeV peak of 60Co between 1.8KeV and 2.2KeV. The energy resolution of 2.0 Kev and relative efficiency of 23% at 1.33Mev was achieved in the system with the counting time of 36000 seconds to reduce the statistical uncertainty.

CALCULATION OF ACTIVITY

Calculations of count rates for each detected photopeak and radiological concentrations (activity per mass unit or specific activity) of detected radionuclides depend on the establishment of secular equilibrium in the samples.

The activity concentration in Bqkg-1 (A) in the environmental samples was obtained as follows:

$$A = \frac{N_p}{e \times \eta \times m}$$

Where Np = net count rate (cps), measured count rate minus background count rate, *e* is the abundance of the γ-line in a radionuclide, η is the measured efficiency for each gamma-line observed for the same number of channels either for the sample or the calibration source, and m the mass of the sample in kilograms.

RESULTS AND DISCUSSION

Activity Concentration of ^{238}U, ^{232}Th and ^{40}K:

The activity concentration of natural radionuclides (^{238}U, ^{232}Th and ^{40}K) for all samples are determined and shown in Table 1. The radionuclides observed with reliable regularity belonged to the decay series chain headed by ^{238}U and ^{232}Th as well as the non-series ^{40}K. Table 1 illustrates the activity of the natural radionuclides (^{238}U, ^{232}Th and ^{40}K) in the soil and water samples. ^{238}U activity in the soil samples is distinctly higher than that of ^{232}Th with a mean activity of 27.41± 9.97Bq/kg, the variations among the radiation levels in soil of different countries may be linked to the wide variations in geological formations of different types of soil (Senthilkumar, 2010).

Soil samples (A1-A8) collected from the reclaimed waste-dumpsite are of relative higher values of radionuclides compared with the control samples (A9 and A10) and is due to the radionuclides concentration contributed by waste from medical sources of diagnosis co-disposed with other hazardous wastes in the reclaimed waste-dumpsite. A1 and A8 have relatively high concentration of K-40 compared to all other samples in the studied areas.

^{232}Th concentration in the soil samples is found to be lower than those of both ^{238}U and ^{40}K with a mean activity of 19.27± 8.14Bq/kg. The activity of ^{40}K is observed comparatively higher than ^{232}Th and ^{238}U in all sampling locations studied with an average of 326± 66.74Bq/kg in soil and with an average of 24.77±8.33Bq/l in water samples.

^{238}U concentration in water samples ranges between 5.99±2.10 to 9.41±2.65Bq/l with the mean value of 7.92± 2.69Bq/l.

^{232}Th concentration in the water samples ranges between 4.76±2.08 to 8.32±2.45Bq/l and have a mean value of 6.96± 2.37Bq/l.

^{238}U activity in some water samples is higher than that of ^{232}Th, this is because ^{238}U is moderately soluble in natural water (Ashraf et al., 2001).

The activity concentration of ^{238}U,^{232}Th and ^{40}K in water were higher than the world permissible value of 10.0, 1.0 and 10.0Bq/l (WHO, 2008)

The activity concentration of ^{238}U,^{232}Th and ^{40}K in soil were lower than the world permissible value of 35.0, 30.0 and 400.0Bq/kg (UNSCEAR, 2000)

Calculation of Dose:

Absorbed dose rate: The mean activity concentrations of Th and K are converted in to dose rate based on the conversion factor given by UNSCEAR (2000) (Table 2).

$$D = 0.042C_K + 0.429C_U + 0.666C_{Th}$$

Where D is the absorbed dose rate ($nGyh^{-1}$), C_U C_{Th}, C_K are the activity concentrations (Bq/kg) of ^{238}U, ^{232}Th and ^{40}K and 0.429, 0.66 and 0.042 Dose constants of U-238, Th-232 and K-40 in the reclaimed dumpsites respectively.

The absorbed dose rates for the samples under investigation are listed in Table 2. The dose rate for soil samples were found to be between 23.53± 9.11 and 50.39± 15.21nGy/hr with an average value of 38.17± 12.45 nGy/hr which is less than international recommended value 55 nGy/hr. The dose rate due to ingestion of these sources of water ranged from 6.62 to 10.54nGy/hr with an average of 9.03± 3.07nGy/hr in the study areas, Water sample from W6 had the highest absorbed dose rate level. Water sample from W3 were next to W6 in dose content, followed by W7, W10, W4,W2, W5, W1, and W8 in that order. No significant difference in radionuclide concentration was shown by the water samples of the reclaimed waste-dumpsite area and other sources (W4 and W10), this is attributed to frequent migration of radionuclides in the direction of flow of water.

The radium equivalent (Raeq)

Radium equivalent activity (Bq/kg) is a guide which is suitable to compare the specific activities of samples contains of different concentration of ^{226}Ra, ^{232}Th, and ^{40}K.It is defined based on the assumption that 10 Bq/kg ^{226}Ra, 7Bq/kg ^{232}Th and 130 Bq/kg ^{40}K produce the same gamma dose rate. Therefore radium equivalent activity depends on activities of Ra, Th and K radionuclides. It is defined as;

$$Raeq = C_{Ra} + 1.43C_{Th} + 0.077C_K$$

Where Raeq is the radium equivalent activity and A_{Ra}, A_{Th} and A_K are the specific activities of Ra, Th and K, in Bq kg^{-1}, respectively (Tufail et al., 1992).

Annual Gonnadal Equivalent Dose (AGED)

The annual gonnadal equivalent dose (AGED) the active bone marrow and the bone surface cells are considered as organs of interest by UNSCEAR (1988). The AGED for the resident of a building using a material with given activity concentration of ^{226}Ra, ^{232}Th and ^{40}K was calculated using the equation.

$$AGED\ (\mu Sv/yr) = 3.09C_{Ra} + 4.18C_{Th} + 0.314C_K$$

Where C_{Ra}, C_{Th} and C_k are the radioactivity concentration of ^{226}Ra, ^{232}Th and ^{40}K.

Radiological Hazard Indices:

The Gamma ray radiation hazards due to the specified radionuclides in soils and waters are assessed by calculating different indices. Even though total activity concentration of radionuclides is calculated, it does not provide the exact indication about the total radiation hazards. Also these hazard indices are used to select the right materials.

Hazard Indices (H_{ex} and H_{in}): The two indices are that represent the external and internal radiation hazards. These indices are calculated (table 2) by following relation (Orgun *et al.,* 2007).

$$H_{ex} = \frac{C_{Ra}}{370} + \frac{C_{Th}}{259} + \frac{C_K}{4810}$$

$$H_{in} = \frac{C_{Ra}}{185} + \frac{C_{Th}}{259} + \frac{C_K}{4810}$$

Where C_U, C_{Th} and C_K are the mean activity concentrations of ^{238}U, ^{232}Th and ^{40}K in Bq/Kg respectively.

The calculated values of Ra_{eq}, AGED, H_{ex} and H_{in} for the soil samples studied ranged between 50.84 and 104.32Bq/kg for Ra_{eq} with an average value of 80.08Bq/kg. The Ra_{eq} of the soils samples were below the recommended value of 370Bq/kg (UNSCEAR 1982).

The annual gonnadal equivalent dose ranged from 161.09 to 357.86µSv/yr with the mean value of 267.63µSv/yr compared to Ademola et al (2010) of 48.9 to 77.5µSv/yr, and which is lower than the world average of 0.30mSv/yr. The results of AGED shows higher values in some samples (A1, A3, A5, A7 and A8) compared to the standard limit of 0.3mSv/yr. This shows that the immediate environment is impacted.

0.137 and 0.282 for H_{ex} with an average value of 0.2162. 0.188 and 0.347 for H_{in} with an average value of 0.2903. These values are far below the criterion limit (H_{ex} and H_{in} less than or equal to 1) for the European Commission on Radiation Protection reports (1999). The external hazard, radon and its short-lived products are also hazardous to the respiratory organ and can cause cancer (Xinwei, 2004).

The calculated values of Ra_{eq}, AGED, H_{ex} and H_{in} for water samples studied ranged between 14.467 and 23.380 Bq/l for Ra_{eq} with an average value of 19.807Bq/l. 45.21 and 72.721µSv/yr of AGED with average value of 61.423µSv/yr, 0.0385 and 0.0627 of H_{ex} with an average value of 0.0532. Also 0.0372 and 0.0877 of H_{in} with an average value of 0.0697. This shows that immediate water sources of environment are contaminated and via mobility of water contaminants other water sources are affected. Eliozu reclaimed waste-dumpsite, residential houses are located close to the landfill, about 50-100metres away, and therefore the immediate environment is impacted. Residential, Scavengers and workers in area are exposed to different doses of radiation, since radiations have harmful effect on the human body, then they could suffer such debilitating medical disease such as radiation poisoning, cancer and cell mutation.

The hazard indices (H_{in} and H_{ex}) should be less than unity for it to be regarded as safe. The calculated values are of $0.07Bql^{-1}$ and 0.05Bq/l (H_{in} and H_{ex}) which are comparable to standard and are far lower than the recommended safety limit. The mean Ra_{eq} obtained for all water samples is less than the maximum recommended limits of 370 (UNSCEAR 1982) and indicates that all the soil samples investigated are radiologically safe and will pose no health effects on the populace. Therefore the average of the radioactivity hazard indices and radium equivalent values are far less than restricted levels for the public. So only if progressive activities occur hence some precautions such treatment from water sources should be follow and take into consideration for the public residences in this area.

Activity Utilization Index (I):

The samples are also examined whether it facilitate the dose criteria when it used as building material. For that reason, the Activity utilization Index (I) is calculated using the equation given by Tzortzis and Haralabos (2003). The calculated 'I' values for all the samples are presented in table2. The values range from 0.32 to1.28 with an average of 0.58 and 0.09 to 0.14 with an average of 0.12 for soil and water samples, exhibit that 'I' (less than) <2, which conform to an annual effective dose < (less than) 0.3 mSv/y (El-Gamal *et al.*,2007).

The Annual Effective Dose Equivalent (AEDE):

The annual effective dose equivalent received by a member is calculated from the absorbed dose rate by applying dose conversion factor of 0.7 Sv/Gy and the occupancy factor for outdoor and indoor was 0.2(5/24) and 0.8(19/24), respectively (Veiga *et al.*, 2006). The annual effective dose is determined using the following equations

$$AEDE\ (Outdoor)\ (\mu Sv/y) = (Absorbed\ dose)\ nGy/h \times 8760h \times 0.7\ Sv/Gy \times 0.2 \times 10^{-3}$$

$$AEDE\ (indoor)\ (\mu Sv/y) = (Absorbed\ dose)\ nGy/h \times 8760h \times 0.7\ Sv/Gy \times 0.8 \times 10^{-3}$$

The calculated indoor and outdoor AEDE values are quoted in table 2. The minimum, maximum and mean value for outdoor and indoor in water is found to 8.12 Sv/y, 13.14 Sv/y and 11.07 Sv/y, respectively and 32.48 Sv/y, 52.54 Sv/y and 44.30 Sv/y, respectively while in soil sample for outdoor is 28.86 Sv/y, 61.80 Sv/y and 46.81 Sv/y, respectively and indoor of 115.43 Sv/y, 247.19 Sv/y and 187.25 Sv/y, respectively.

Excess Lifetime Cancer Risk (ELCR): Excess Lifetime Cancer Risk (ELCR) is calculated using below equation and shown in Table 2.

$$ELCR = AEDE \times DL \times RF$$

Where AEDE, DL and RF is the annual effective dose equivalent, duration of life (70 years) and risk factor (per Sv), fatal cancer risk per sievert. For stochastic effects, ICRP 60 uses values of 0.05 for the public (Taskin *et al*., 2009). The range of ELCR is between 0.028 x 10^{-3} to 0.046 x 10^{-3} with an average of 0.039 x 10^{-3} for water samples and 0.1010 x 10^{-3} to 0.2163 x 10^{-3} with an average of 0.1638 x 10^{-3} for soil samples.

CONCLUSION

The absorbed dose rate and excess life cancer risk due to natural radioactivity in soil and water around reclaimed waste dumpsite in the city of Port Harcourt have been carried out Rivers state. The average activity concentrations of soil and water samples were within the world permissible value. Although some extreme values have been determined from water samples in it activity concentration indicating some elements of contamination of water body. The average outdoor terrestrial gamma doses are higher than world average. The other calculated radiological hazard indices are below the acceptable limit (Safety Limit). The calculated activity utilization index is less than 2; this indicates that the Eliozu's soils and waters can be used for construction of buildings.

.

REFERENCE

[1]. NRC -National Research Council, (**1980**): Health risks of radon and other internally deposited alpha-emitters. BEIR IV. National Academy of Sciences, Washington, D.C., 1980. 602 pp.
[2]. Senthilkumar B, Dhavamani V, Ramkumar S and Philominathan P (**2010**). Measurement of gamma radiation levels in soil samples from Thanjavur using ϒ-ray spectrometry and estimated of population exposure. J. Med. Phys. 2010.
[3] Ademola J.A., and Atare E.E. (**2010**). Radiological assessment of natural radionuclides in soil and around crude oil flow and gas compression station in the Niger Delta, Nigeria. within Radioprotection, Vol 45, No 2, 219-227.
[4]. Iloeje N.P., (**1972**). A new Geography of West Africa Longman Group Ltd. Nigeria 22-26.
UNSCEAR (2000). "Sources, Effects and Risks of Ionizing Radiation," Report to the General Assembly, New York.
[5]. Xinwei L.(**2004**)''Natural radioactivity in some building materials and by products of Shaanxi, China. Journal Radioanal Nuclear Chemistry. 262,775-777.
[6]. Udom, G.J.and Esu, E.O. (**2004**). A preliminary Assessment of the Impact of Solid wastes on soil and groundwater system in parts of Port-Harcourt City and its Environs, Nigeria Vol. 4(1) 23-32
[7]. European Commission on Radiation Protection (**1999**). Radiological Protection Principles Concerning the Natural Radioactivity of Building Materials. European Commission, Brussels Report. No.112
[8]. Tufail, M., Ahmed, M., Shaib, S., Safdar, A., Mirza, N.M., Ahmed, N., Zafar, M.S., Zafar, F.I., **1992**. Investigation of gamma-ray activity and radiological hazards of the bricks fabricated around Lahor, Pakistan. Pak. J. Sci. Ind. Res. 34, 216 – 220.
[9]. UNSCEAR "Sources and Effects of Ionizing Radiation". Report on the General Assembly with Scientific Annexes, vol. 1. UN,New York, (**2000**).

[10]. Orgun, Y., N. Altinsoy, S.Y. Sahin, Y. Gungor, A.H. Gultekin, G. Karaham and Z. Karaak, **2007**. Natural and anthropogenic radionuclides in rocks and beach sands from Ezine region(canakkale), Western Anatolia, Turkey. Applied Radiation and Isotopes., 65: 739-747.
[11] Taskin, H., M. Karavus, P. Ay, A. Topuzoglu, S. Hindiroglu and G. Karahan, **2009**. Radionuclide concentrations in soil and lifetime cancer risk due to the gamma radioactivity in Kirklareli, Turkey. Journal of Environmental Radioactivity., 100: 49-53.
[12]. Tzortzis M and Haralabos Tsertos, **2003**. Gamma radiation measurements and dose rates in commercially used natural tiling rocks (granites). J. of Environmental Radioactivity., 70: 223-235.
[13]. El-Gamal, A., S. N asr and A. El-Taher, **2007**. Study of the spatial distribution of natural radioactivity in Upper Egypt Nile River sediments. Radiation Measurements., 42: 457-465.
[14]. Veiga, R.G., N. Sanches, R. M.Anjos, K. Macario, J.Bastos, M.Iguatemy, J.G Aguiar, A.M.A. Santos, B. Mosquera, C. Carvalho, M. Baptista Filho and N.K. Umisedo, **2006**. Measurement of natural radioactivity in Brazillian beach sands. Radiation measurements., 41:189-196.