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Research Article

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Evaluation of Radiological Hazard Indices in Soil Samples and Excess Lifetime Cancer Risk around Delta Steel Company Ovwain Aladja, Delta State

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Abstract This work presents radionuclide concentrations (^{238}U and ^{232}Th and ^{40}K,) of soil samples in Delta Steel Company Ovwain Aladja in Udu local government of Delta state, Nigeria using gamma-ray spectroscopy [NaI(TL)]. Six communities were sampled, a total of twelve (12) representative samples (two soil sample per community) were collected for the study. The obtained mean activity radionuclide concentrations of (^{238}U and ^{232}Th and ^{40}K,) in soil samples from the studied area are, 24.83±3.87 Bq/kg, 24.45±2.29 Bq/kg and 336.23±3.5 Bq/kg respectively. These obtained radionuclide values when compared with standard, it was observed that the obtained values are below world standard. The calculated mean values for radiological hazard indices such as radium equivalent (35.11±21.71 Bq/Kg), representative index (0.638 msv/y) external hazard (0.227 msv/y), internal hazard (0.283 msv/y) absorbed dose (D) (32.99 nG/h), AEDE (outdoor) (47.26 µsv/y), AEDE (indoor) (188.7 µsvy^{-1}) and ELCR (0.166 x 10^3 µsvy^{-1}) are all below world average values when compared. Despite the low values for activity concentrations and the calculated radiological hazards in soil samples some communities have high values which exceeded the world standard. However, exposure to soil in this environment may not be detrimental to man and his environment, but long term exposure may cause effect.

Keywords Radiological, Concentrations, Soil, Radionuclide, Environment, Exposure

Introduction

The important of soil is highly evident in human's life and in everyday activities. Soils are used for the purpose of planting of crops, vegetables, buildings (construction) materials to man, soil is a mineral deposit formed from the process of withering and rock erosion [1]. Uranium and thorium are the major radio nuclide that produces radiation [2]. However, importance of soils to man cannot be over emphasised in relative human activities, hence there is need to evaluate the natural radioactivity concentration in soils for communities around the Delta Steel Company Ovwain Alajda, in Udu local government area of Delta state with a view to assess the radiological health effects to the people living in these communities. When human and the environment is be exposure to radiation the following health problems will occur; skin cancers, leukaemia, kidney cancer, lung diseases, acute leucopoenia, anaemia, paganise, hepatic, bone cancer etc [3].

Human beings from time memorial has always been exposed to naturally occurring radioactive materials (NORMs) within and outside the planet earth, which is mainly caused by the impact of naturally occurring radioactive material (NORM) present in the soils, rocks, water, food, air and plants, that are well spread in the earth's environment. Naturally radioactivity in soils emanates from Uranium, Potassium and Thorium (^{238}U, ^{232}Th and ^{40}K). Human activities such as smelting of metalliferous ores, processing of uranium ores, mineral sands, mining, drilling, processing and burning of fossil fuels have raised the radiation concentrations of naturally occurring radioactive materials in the environment [4-5].

Delta Steel Company, Aladja- Ovwian, Delta State, South West Nigeria, is one of the major steel companies in Nigeria where iron ores and scrap metals are the major source of raw material for steel production. During production, iron ores and scrap metals are recycled, some of these scrap metals may have been contaminated with radionuclides from scales, sludge, corrosion. During Steel making, wastes (effluent) are be discharge into the water body and the communities surrounding the steel company farm land and polluted plumes (toxic waste materials) are emitted into the atmosphere. These wastes will eventually settle on farmlands, farm crops and in communities' sources of water such as dug wells, river bodies, stream and are as well inhaled continuously in the atmosphere. Vegetables, Crops and other items grown in the farmland may absorb these radionuclide (Uranium, Potassium and Thorium) elements from the soil and animals during grazing of the plant leaves may also absorb the radionuclide, sea foods also absorb radionuclide. When these contaminated crops and aquatic animals are eventually eaten, radioactive elements get into the body and could reach hazardous levels depending on the type of radioactive element present, the rate of consumption of these food/ water products or the extent to which the food/water have been contaminated. This, no doubt is a problem to the communities in the immediate environs of the steel company, in addition to the contamination arising from the inhalation of radioactive dusts. The soil which man depends on has now been polluted with toxic materials which are equally detrimental to human health and ecosystem. Several researches have been carried out on activity concentration in soil samples in different areas with a view of knowing the effect and possible proteome solution [6-9]. The present research evaluates the radiological hazard indices in Soil samples and excess lifetime cancer risk around Delta Steel Company Ovwain Aladja, Delta State due to the steel processing activities. It is expected that this research would assist the government, oil companies and ingredients of the study area in enacting environmental policies that will cub radiation hazards in Nigeria.

Materials and methods

Description of the study area

Six communities were sampled in the evaluation of radiation exposure due to steel making company that discharges waste in to the river waters and steel making plume into the atmosphere. The studied communities are in Udu local government area Delta State, Nigeria. The communities are situated some few kilometres away from the steel company. The area is approximately between latitudes 5°00 and 6°.30' North and longitudes 5°00 and 6°.45' East of Delta State, Nigeria [10]. The map of the locations is shown in Fig. 1.

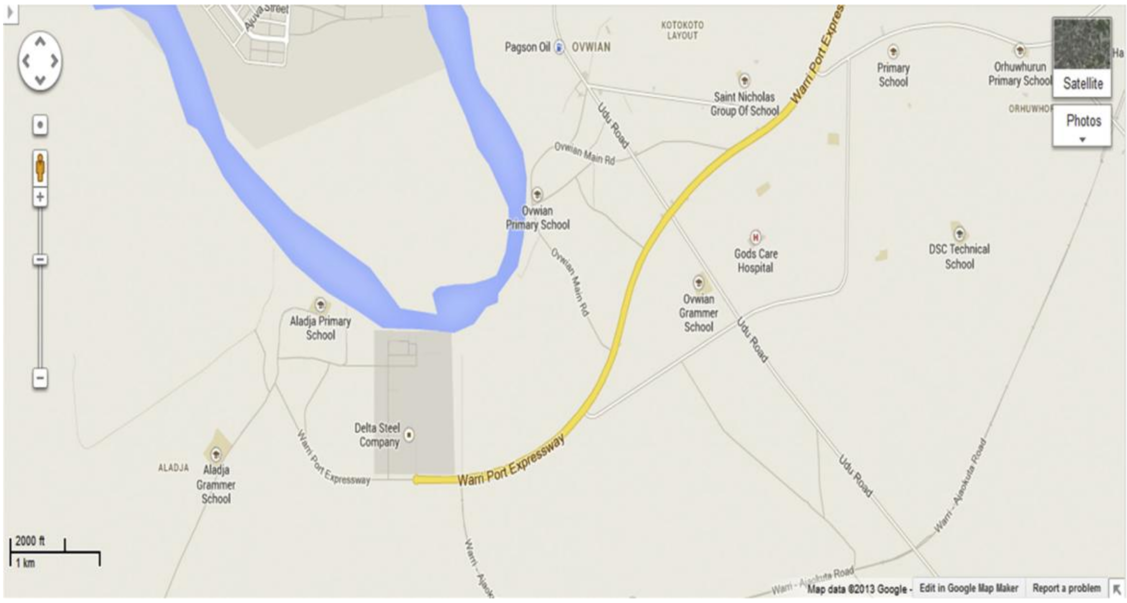

Figure 1: Description of the study area [11]

Sample collection and preparation

Twelve soil samples were collected; two soils samples each from the six communities studied. Standard methods were used in the collection of soil samples. At the verge of sampling, soil samples collected were sealed in black polythene bag and labelled properly, to avoid cross contamination before taking to the laboratory (Centre for Energy Research and Development (CERD) Obafemi Awolowo University Ile-ife, Nigeria), for instrumental analysis of samples using gamma spectroscopy. Before the instruments analysis, soil samples were air-dried at room temperature for at least fifteen days, and then oven dried with a temperature of about 90^0c for 24 hours in other to evacuate moisture content and reduce the samples to a constant weight. The dried samples were milled and sieved using a mesh of 2mm. About 10g of the soil samples were then sealed for a period of 28 days in a plastic container for a secular equilibrium to be attained. The soil samples were subjected to gamma ray spectrometry analysis in other to determine the radio nuclides concentration in the samples.

Sample Analysis

The samples were analyzed at CERD Gamma Ray Spectrometry Laboratory, Obafemi Awolowo University Ile-ife, using a thallium activated 3x3 Sodium iodide [Nal(Tl)] detector connected to ORTEC 456 amplifier. The detector, enclosed in a 100mm thick lead shield, was connected to a computer program SAMPO 90 window that matched gamma energies to a library of possible isotopes. Since the accuracy of the quantitative measurements Is depended on the calibration of the spectrometry system and adequate energy. Background measurement and efficiency calibration of the system was made possible using Cs-137 and Co-60 standard sources from IAEA, Vienna. Spectrum were accumulated for background for 29000s at 900 volts to produce strong peaks at gamma emitting Energies of 1460Kev for 40k; 609keV of 214Bi and 911keV of 228Ac, which were used to estimate concentrations of 238U and 232Th, respectively. The energy resolution detector using Cs-137 and Co standards is 39.5% and 22.2% respectively while the activity of the standards at the time of calibration is 25.37KBq for Cs-137 and 4.84 KBq for Co- 60. The background spectra, measured under the same conditions for both the standard and sample measurements, were used to correct the calculated sample activities concentration.

Each sealed sample was placed on the sodium iodide detector and counted for 36000 seconds. The gamma-ray counting of the samples was performed on a lower gamma ray spectrometer consisting of a detector; the sodium Iodide (Nal) coupled with an amplifier which amplifies the incoming signals and integrates them to volts (0=10 volts). It also consists of an analog to digital converter (A.D.C) and an S100 Multi-Digital Analyzer card hosted in a desktop computer. The output was displayed as a spectrum on the computer screen and the gamma emitting radionuclide's present were identified with their characteristics pulse heights.

Radiological Hazard Indices

Radium Equivalent Activity Index (Raeq)

The radium equivalent concept allows a single index or number to describe the gamma output. From different mixtures of uranium, thorium and potassium in soil samples from different local Government Area and their communities Mahur et al, 2008. It is written mathematically according to UNSCEAR, 2000 [12]:

$$Ra\,(eq) = C_{Ra} + I\,.43C_{Th} \pm 0.077C_k \qquad 1$$

Absorbed Dose Rate (D)

The contribution of natural radionuclide to the absorbed dose rate in air (D) depends on the natural specific activity concentration of ^{238}U, ^{40}K and ^{232}Th. Terrestrial radio nuclide, gives the highest quantity of gamma radiation. There is a direct link between terrestrial gamma radiation and radionuclide concentrations, Avwiri et al., (2015). If a radionuclide activity is known then its exposure dose rate in air at 1m above the ground can be calculated using the equation below.

$$D = 0.462A_U \pm 0.621A_{Th} + 0.0417A_k \qquad 2$$

Where D is the dose rate in $Gyli^{-1}$ and Au, A_{Th}, and A_K (are the concentration of uranium, thorium and potassium respectively. UNSCEAR, (2000), has given the dose conversion factor for converting the activity concentration of ^{238}U, ^{40}K and ^{232} TH into doses [(Gyh^{-1} per Bql^{-1})] as 0.462, 0.621 and 0.0417, respectively.

External Hazard Index (Hex):

The external hazard index (Hex) is used to estimate the level of radiological risk of the samples to the immediate environment. The value of hex must be less than (unity), one. The value for Hex was obtained using the expression below:

$$\text{Hex} = \frac{CR_a}{370} + \frac{C_{Th}}{259} + \frac{C_k}{4810} \qquad 3$$

Where C_{Ra}, C_{Th} and C_k are the average activity concentration of ^{226}Ra, ^{232}Th and ^{40}K respectively in Bq/kg as stated earlier.

Internal Hazard Index (Hm)

In addition to external hazard index, radon and its short lived products are also hazardous to the respiratory organs. The internal exposure to radon and its daught or progenies due to the consuming of water is quantified by the internal hazard Index Him, which is given by the expression below [13].

$$\text{Hin} = C_{Ra}/\ 185 + C_{Th}\ 259 \pm C_k\ /\ 4810 \qquad 4$$

Where C_{Ra}, C_{Th} and C_k, are average activity concentration of ^{226}Ra, ^{232}Th and ^{40}K respectively as stated earlier.

Excess Lifetime Cancer Risk (ELCR)

This gives the probability of developing cancer over a lifetime at a given exposure level considering (70 years) as the average duration of life for human being. It is given as [14];

$$\text{ELCR} = \text{AEDE x DL x RF} \qquad 5$$

Where AEDE is annual effective dose equivalent; DL' average duration of lifetime (estimated to be (70 years) and RF is the Risk Factor (Sv) i.e. Fatal cancer risk persievert. For stochastic effects, KRP uses RF as 0.05 for the public.

Annual Effective Dose Rate (Outdoor)

The annual effective dose (msvy^{-1}) was calculated using the equation below [12]. Annual effective dose rate (msvy^{-1}) = D (Gyrhj^{-1}) x 8760hyrh^{-1} x 0.7 x (10^3 mSv/10^9) Gy x 0.2 x 10^{-3}.

$$E_{ff}\ \text{Dose} = D\ 1.2264\ X\ 10^{-3}. \qquad 6$$

Where D is effective dose rate, UNSCEAR, [12] has recommended 0.7 Sv/Gy as the conservation coefficient from absorbed dose in air to effective dose and 0.2 (5/24) as the value for the outdoor occupancy factor.

The Annual Effective Dose Rate (Indoor)

The Annual effective dose rate (indoor was calculated using the formula below:

Effective dose (msvy^{-1}) = (msvy^{-1}) = D (Gyrhj^{-1}) x 8760hyrh^{-1} x 0.7 x (10^3 mSv/10^9) Gy x 0.8 x 10^{-6} 7

The United Nation Scientific committee on the effect of Atomic Radiation UNSCEAR, [12] has recommended 0.7 Sv/Gy as the conversion coefficient from absorbed dose in air to effect dose and 0.8 (19/24) as the value for the indoor occupancy factor.

Representative level index (1 yr)

This is used to estimate the level of gamma radio activity hazard associated with different concentrations of some radio nuclide in specific investigated samples and is called representative level index [12], the expression for it is given as:

$$\text{Iyr} = \frac{AR_a}{150} + \frac{A_{Th}}{100} + \frac{A_k}{1500} \qquad 8$$

Where, A_{Ra}, A_{Th} and A_k are the average activity concentration.

Result and Discussion

Table 1: Specific activity concentration of ^{238}U ^{40}K and ^{232}Th (Bq/kg) results in soil samples in the different communities

S/No	Communities	Activity Concentrations		
		^{238}U (Bq/kg)	^{232}Th (Bq/kg)	^{40}K (Bq/kg)
1	Ovwian A	34.29 ± 3.06	30.11 ± 1.23	422/40 ± 2.65
2	Ovwian B	31.57 ± 4.75	29.01 ± 0.65	364.15 ± 1.47
	Mean	32.93 ± 3.91	29.56 ± 0.94	393.20 ± 2.06
3	Ujevwu A	22.64 ± 2.93	13.48 ± 3.01	303.82 ± 2.20
4	Ujevwu B	20.79 ± 3.56	17.77 ± 2.80	296.19 ± 5.70
	Mean	21.72 ± 6.49	15.63 ± 2.91	300.01 ± 3.95
5	Aladja A	29.61 ± 5.28	34.20 ± 4.87	416.30 ± 4.87
6	Aladja B	33.42 ± 3.37	27.18 ± 2.37	384.23 ± 2.53
	Mean	31.52 ± 4.33	30.69 ± 1.99	400.27 ± 3.7
7	Obubu A	26.19 ± 2.34	29.90 ± 2.15	377.14 ± 3.41
8	Obubu B	30.38 ± 2.02	23.14 ± 1.40	412.31 ± 5.67
	Mean	23.09 ± 2.18	26.52 ± 1.78	394.73 ± 4.54
9	Owasie A	21.19 ± 3.25	25.50 ± 1.18	262.69 ± 2.28
10.	Owasie B	24.35 ± 4.13	18.32 ± 4.08	259.17 ± 1.38
	Mean	22.77 ± 3.69	21.91 ± 2.63	260.93 ± 1.83
11	Ekete A	17.21 ± 3.46	25.11 ± 2.24	256.98 ± 2.57
12	Ekete B	16.69 ± 1.74	19.60 ± 4.71	279.52 ± 7.17
	Mean	16.95 ± 2.60	22.36 ± 3.46	268.25 ± 4.87
	Average	24.83 ± 3.87	24.45 ±2.29	336.23 ± 3.5

Table 2: Mean values for activity concentration in the different communities

S/No	Communities	Activity Concentrations		
		^{238}U (Bq/kg)	^{232}Th (Bq/kg)	^{40}K (Bq/kg)
1	Ovwian	32.93 ± 3.91	29.56 ± 0.94	393.20 ± 20
2	Ujevwu	21.72 ± 6.49	15.63 ± 2.91	300.01 ± 3.95
3	Aladja	31.52 ± 4.33	30.69 ± 1.99	400.27 ± 3.7
4	Obubu	23.09 ± 2.18	26.52 ± 1.78	394.73 ± 4.54
5	Owasie	22.77 ± 3.69	21.91 ± 2.63	260.93 ± 1.88
6	Ekete	16.95 ± 2.60	22.36 ± 3.46	268.25 ± 4.87
Mean		24.83 ± 3.87	24.45 ± 2.29	336.23 ± 3.5
[12]		35	30	400

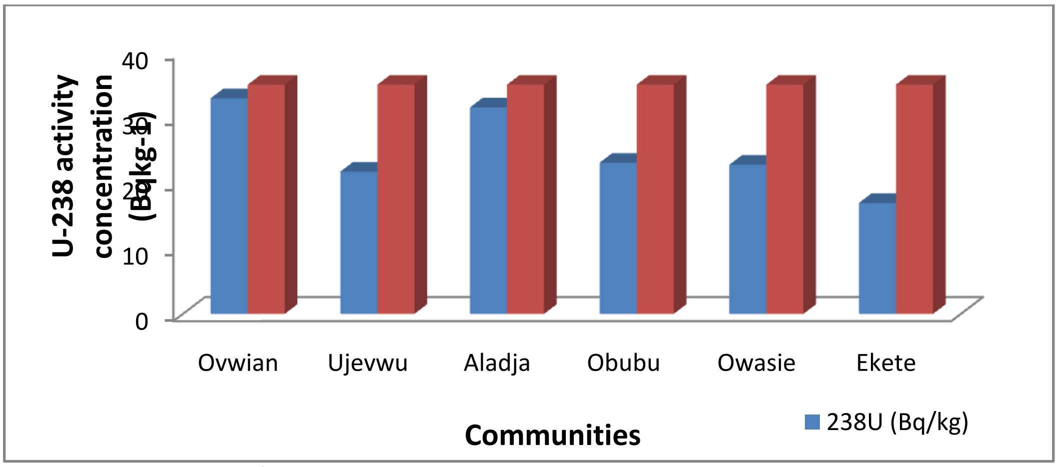

Figure 2: Comparison of ^{238}U activity concentration ($Bqkg^{-1}$) in Soil with standard in all the communities

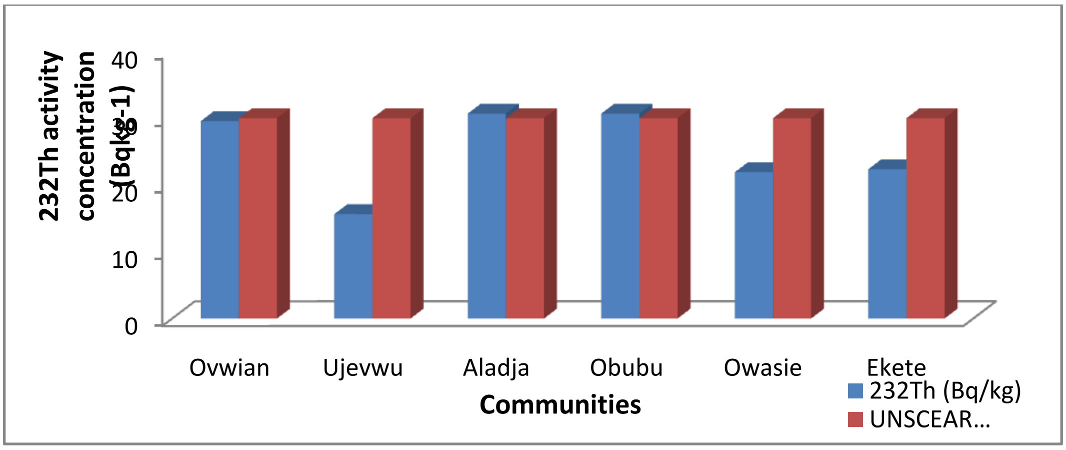

Figure 3: Comparison of ^{232}Th activity concentration (Bqkg^{-1}) in Soil with standard in all the communities

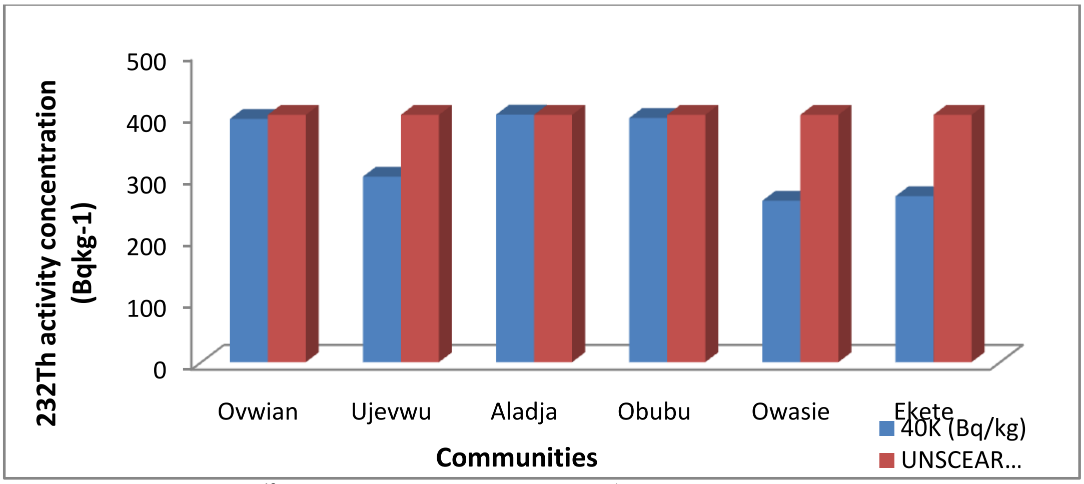

Figure 4: Comparison of ^{40}K activity concentration (Bqkg^{-1}) in Soil with standard in all the communities

Table 3: Calculated Parameters for Radiation Hazard indices in Soil sample

S/No	Communities	Raeq.	1yrs	Hax	Hin	D	AEDE (Outdoor)	AEDE (Indoor)	ELCx10^{-3}
1	Ovwian A	110.48	0.811	0.296	0.310	52.15	63.95	255.8	0.230
2	Ovwian B	101.09	0.743	0.273	0.358	47.78	58.59	234.3	0.205
	Mean	105.78	0.777	0.284	0.334	49.96	61.27	245.05	0.217
3	Ujevwu A	47.75	0.483	0.176	0.237	31.50	38.63	154.5	0.135
4	Ujevwu B	69.00	0.513	0.186	0.112	32.99	41.68	161.8	0.145
	Mean	58.37	0.498	0.181	0.174	32.24	40.15	158.15	0.140
5	Aladja A	110.57	0.816	0.298	0.362	21.26	26.07	104.2	0.910
6	Aladja B	101.87	0.750	0.275	0.365	48.34	59.10	237.1	0.206
	Mean	106.22	0.783	0.286	0.363	34.8	42.50	170.65	0.149
7	Obubu A	97.98	0.725	0.264	0.335	46.39	56.89	227.5	0.199
8	Obubu B	95.20	0.708	0.257	0.339	45.59	55.91	223.6	0.195
	Mean	96.59	0.716	0.260	0.337	45.99	56.4	225.55	0.197
9	Owasie A	77.88	0.571	0.210	0.267	36.57	44.84	179.3	0.156
10	Owasie B	70.50	0.578	0.190	0.256	33.43	40.99	163.9	0.143
	Mean	74.19	0.544	0.2	0.261	35.00	42.91	171.6	0.150
11	Ekete A	72.82	0.537	0.196	0.243	34.26	42.01	168.0	0.147
12	Ekete B	66.24	0.493	0.718	0.224	31.53	38.66	154.6	0.135
	Mean	69..53	0.515	0.151	0.233	32.89	40.33	161.3	0.141

Table 4: Mean Calculated Values for Radiation Hazard indices (mSv/y) in Soil samples

S/No	Communities	Raeq.	Iyrs	Hex	Hin	D	AEDE (Outdoor)	AEDE (Indoor)	ELCx10^{-3}
1	Ovwian	105.78	0.777	0.284	0.334	49.96	61.27	245.05	0.217
2	Ujevwu	58.37	0.498	0.181	0.174	32.24	40.15	158.15	0.140
3	Aladja	106.22	0.783	0.286	0.363	34.8	42.50	170.65	0.149
4	Obubu	96.59	0.716	0.260	0.337	45.99	56.4	225.55	0.197
5	Owasie	74.19	0.544	0.2	0.261	35.00	42.91	171.6	0.150
6	Ekete	69..53	0.515	0.151	0.233	32.89	40.33	161.3	0.141
Average		85.11	0.638	0.227	0.283	32.99	47.26	188.7	0.166

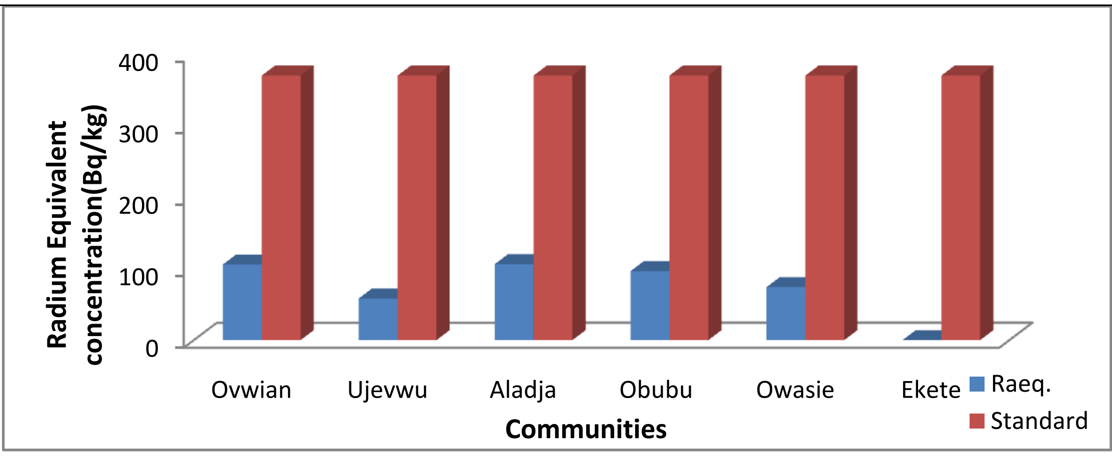

Figure 5: Comparison of Radium Equivalent concentration in Soil with Standard in all the Communities

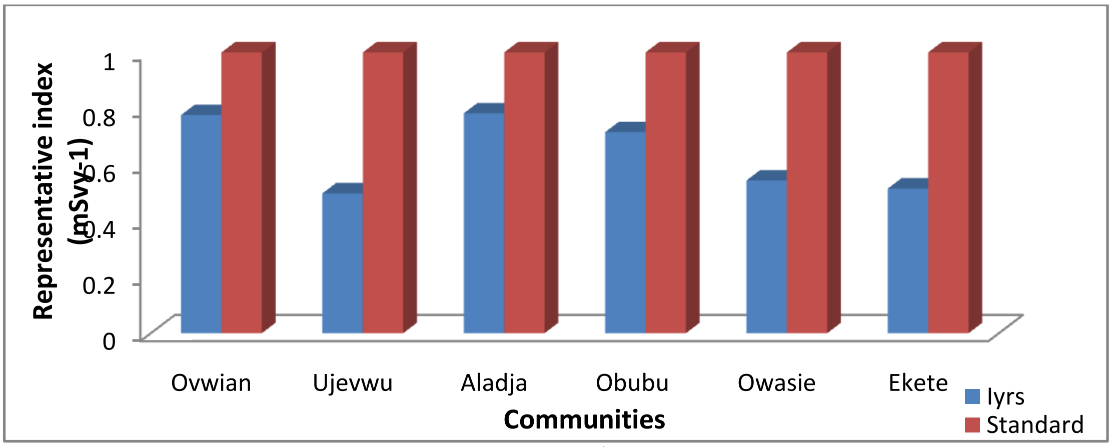

Figure 6: Comparison of Representative index (mSvy^{-1}) in Soil with Standard in all the communities

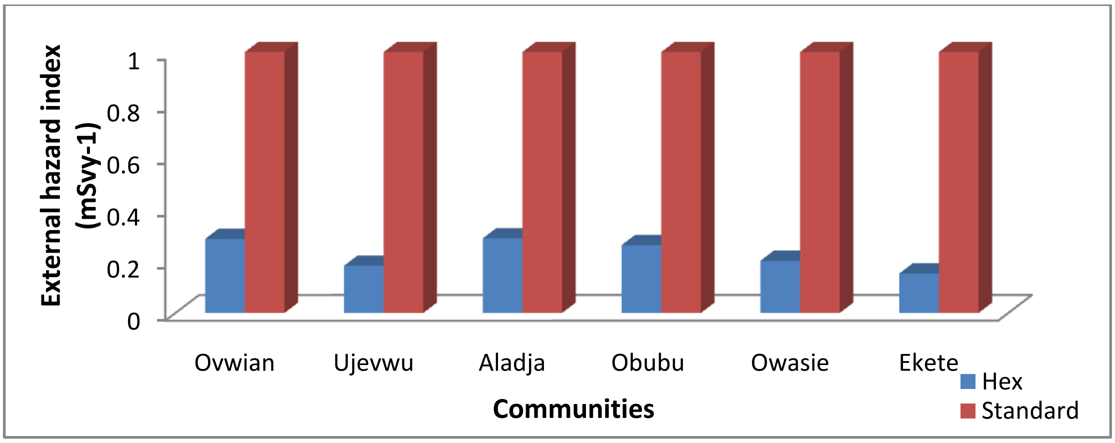

Figure 7: Comparison of External hazard index values (mSvy-1) in Soil with Standard in all the communities

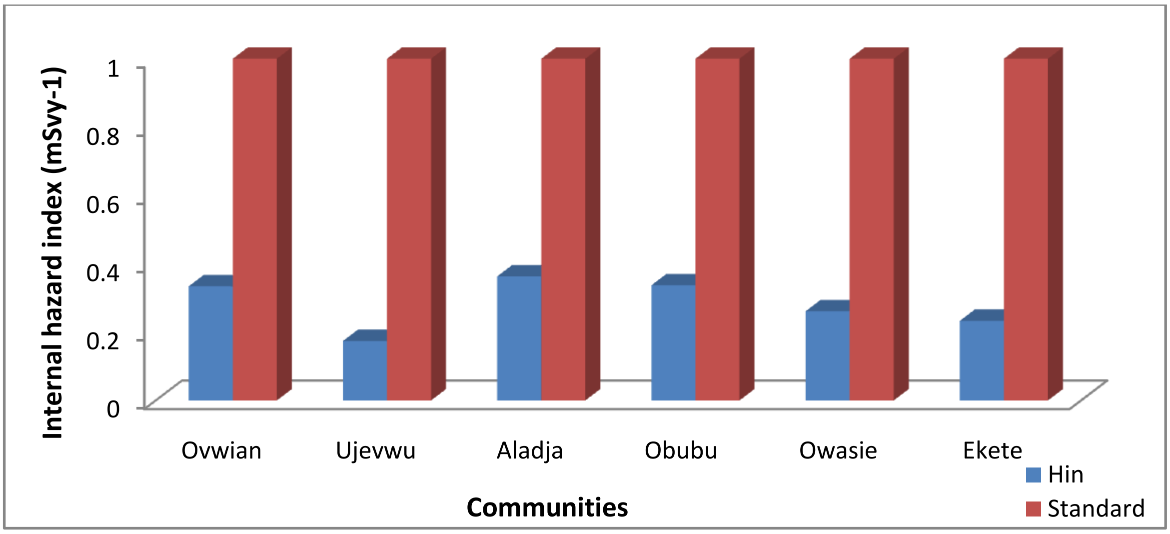

Figure 8: Comparison of Internal hazard index values (mSvy^{-1}) in Soil with Standard in all the communities

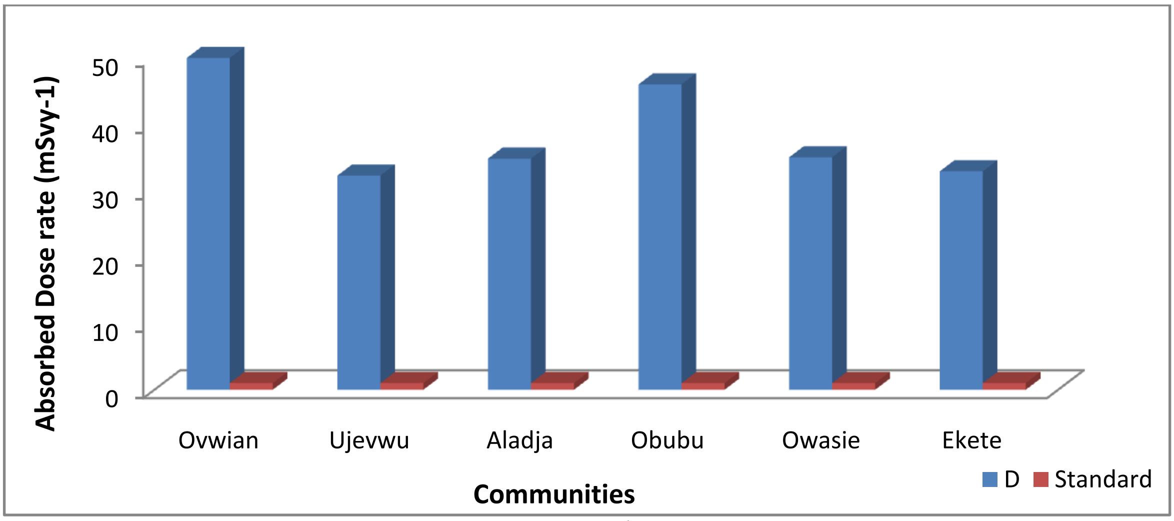

Figure 9: Comparison of Absorbed Dose rate (mSvy^{-1}) in Soil with Standard in all the communities

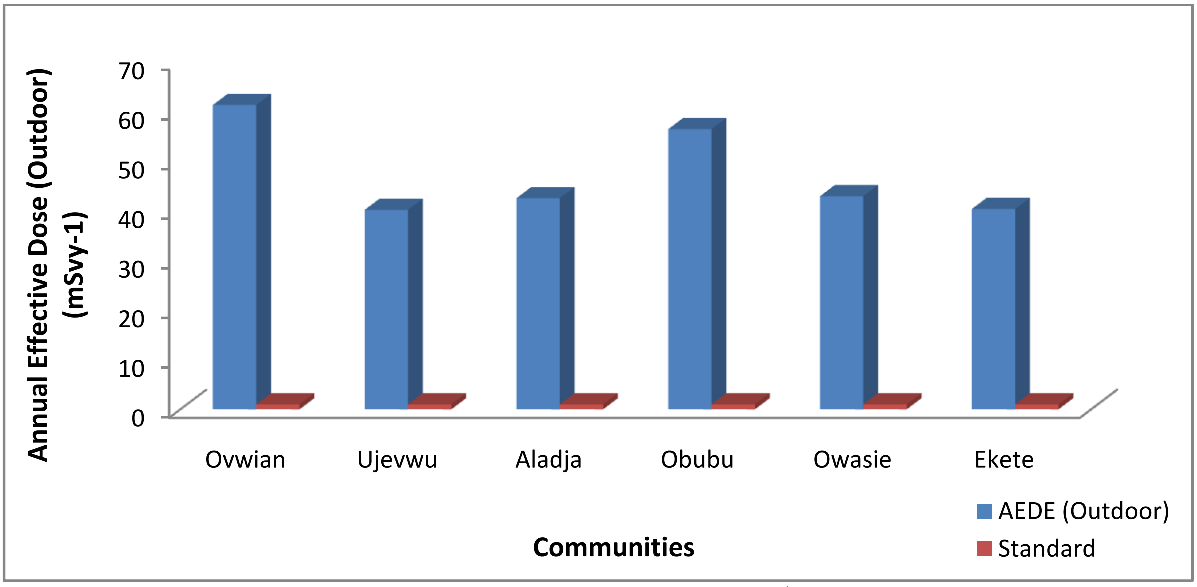

Figure 10: Comparison of Annual Effective Dose (Outdoor) (mSvy^{-1}) in Soil with Standard in all the communities

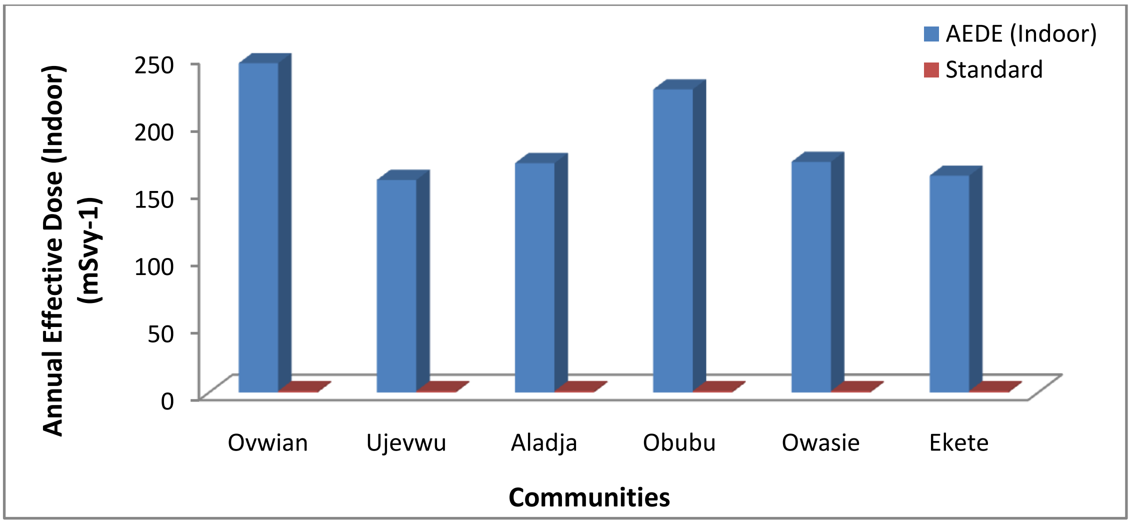

Figure 11: Comparison of Annual Effective Dose (Indoor) (mSvy-1) in Soil with Standard in all the communities

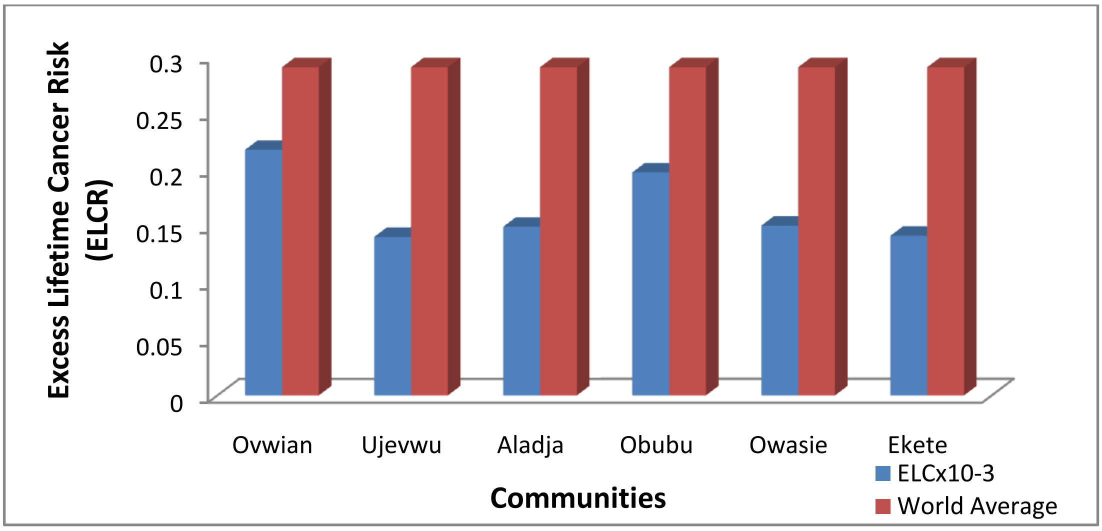

Figure 12: Comparison of Excess Lifetime Cancer Risk (ELCR) in Soil with Standard in all the communities

Naturally occurring radionuclides (^{238}U, ^{232}Th and ^{40}K) studied in the soil samples collected in all the communities around Delta Steel Company Ovwain Aladja in Udu local government area of Delta State of Nigeria are in Tables 1 and 2. The mean activity concentration for ^{238}U ranged from 16.95 ± 2.60BqKg^{-1} at Ekete community to 32.93 ± 3.91BqKg^{-1} at Ovwain community with an average of 24.83 ± 3.87BqKg^{-1}, the mean activity concentration for ^{232}Th ranged from 15.63 ± 2.91BqKg^{-1} at Ujevwu community to 30.69 ± 1.99BqKg^{-1} at Aladja community with an average of 24.45 ± 2.29BqKg^{-1} and mean activity concentration for ^{40}K ranged from 260.93 ± 1.88BqKg^{-1} at Owasie community to 400.27 ± 3.7BqKg^{-1} at Aladja community with an average of 336.23 ± 3.5BqKg^{-1}. Comparing the obtained mean results of soil samples of ^{238}U, ^{232}Th and ^{40}K with UNSCEAR, 2000 standard, it was observed that the obtained mean results for all the radionuclide are below standard values limit of 35Bqkg^{-1}, 30Bqkg^{-1} and 400Bqkg^{-1} respectively, except ^{232}Th that is slightly above the standard values limit as shown in Fig. 2 to 4. The calculated Radiation Hazard indices in Soil samples studied are as showed in table 3 and table 4 above. The mean radium equivalent ranged from 66.24±61.02 BqKg^{-1} - 110.57±40.13 BqKg^{-1} with an average of 85.11±21.71BqKg^{-1}, the results were compared with world average value of (370 BqKg^{-1}), it was observed that the obtained results are lower than the world average value limit. Also, comparing the obtained results with other researched work [6-7], it observed that the obtained values are lower than those reported values. The minimum radium equivalent value is observed at Ekete community while the maximum is at Aladja community. Since the value is below standard, radium equivalent does not pose any significant threat on the life of the dweller and the environment. The representative index (Iyr) ranged from

0.483mSvy^{-1} - 0.216mSvy^{-1} with the average of 0.638mSvy^{-1}. When compared with allowable limits, [12] of 1.0 mSvy^{-1}, it falls below the standard. The level of the external hazard calculated ranged 0.151mSvy^{-1} - 0.298mSvy^{-1} and averaging to be 0.227mSvy^{-1}. The lowest and highest are recorded for Ekete and Aladja respectively. However, most of the obtained values are less than unity. Also the internal hazard calculated ranged from 0.112mSvy^{-1} -0.365mSvy^{-1} with an average of 0.227mSvy^{-1}. The minimum and maximum levels are recorded for Ujevwu and Aladja communities. However the internal hazard, external hazard and the representative gamma index are less than the world permissible value of unity [7]. This implies that the values will not lead to respiratory diseases such as asthma, cancer and external diseases such as erythema, skin cancer and cataracts. The table presents values of indoor and outdoor annual effective dose equivalent ranged from 154.5mSvy^{-1} - 255.8mSvy^{-1} and 26.07mSvy^{-1} - 63.95mSvy^{-1} with an averages of 188.7mSvy^{-1} and 47.2mSvy^{-1} having lowest and highest level in Ujevwu and Ovwian communities for indoor and outdoor respectively. The average values for indoor and outdoor effective dose obtained when compared with the world standard average values (70µsvy^{-1} for outdoor and 450µsvy^{-1} for indoor) [7] are below world standard. The excess lifetime cancer risk (ELCR) in all the study area ranged 35.2 - 0.910 with an average of 0.166. The minimum (ELCR) level been observed in Ujevwu community and maximum (ELCR) level been observed in Aladja community. The average value of excess lifetime cancer risk in this study when compared is less than the world average of 0.29x10^{-3} the absorbed dose rate varies between 21.26-52.15 nGy/h with an average of 32.99 nG/h. since absorbed dose rate itself does not indicate biological effects thus it can be converted to effective dose equivalent for the effect to be significant. Thus, 21.26-52.15 nG/h (0.026-0.064 mSv/y) and the average of 32.99 nG/h transform to 0.040 mSv/y. However the dose equivalent calculated are within the possible limit of 1msv/y in the study areas. Therefore, the radio nuclide concentration of soil samples in the study areas may not pose any immediate detrimental health's challenges but continuous exposure and industrial activities may cause long-term effect on the residents and the environment.

Conclusion

The study of radio nuclide (^{238}U, ^{40}K and ^{232}TH) concentration of soil samples in Udu local Government Area of Delta state Nigeria has been carried out using gamma ray spectrometry (Na 1 (TL)) to determine the soil radioactivity concentration in the study area. The average activity concentration of (^{238}U, ^{40}K and ^{232}TH) are 24.83±3.87 Bq/Kg, 24.45±2.29 Bq/kg and 336.2±3.5 Bq/Kg respectively, when compared are lower than the world average of (35 Bq/Kg, 30 Bq/Kg and 400 Bq/Kg respectively). Despite the low average of radio nuclides in the soil sample of the study areas, some communities like Ovwian, Aladja and Obubu exceeded the world limit value for ^{40}K (400 Bq/Kg) by having 422.40±2.65, 416.30±4.87 and 412.31±5.67 Bq/Kg respectively. Also, for the concentration of thorium in soil samples, two communities slightly exceeded the world average limit values i.e Ovwian (30.11±1.23Bq/Kg) and Aladja (34.20±4.87) as against the bench mark of (30 Bq/Kg). However, this increase is attributed to the activity of Delta steel company and other petrochemical industries sited in Ovwia-Aladjda community. The average values for calculated radiological hazard indices i.e (radium equivalent, representative index, external/internal hazard, mean dose rate) AEDE (outdoor/indoor) and excess life time cancer risk, all falls below world permissible standards. The implication is that the soil in this environment are not detrimental to human health, but continuous exposure can cause ions-term effects, also soils in this area can comfortably be used as a construction material and farm activities.

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