# RADIOMETRIC ASSAY OF HAZARD INDICES AND EXCESS LIFETIME CANCER RISK DUE TO NATURAL RADIOACTIVITY IN SOIL PROFILE IN OGBA/ EGBEMA/ NDONI LOCAL GOVERNMENT AREA OF RIVERS STATE, NIGERIA

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## ABSTRACT

*Naturally occurring radio nuclides ($^{226}Ra$, $^{232}Th$ and $^{40}K$) were measured in soil samples collected from twelve oil fields and their host communities in Ogba/Egbema/Ndoni Local Government Area (ONELGA) of Rivers State using gamma spectroscopy. The mean activity concentration of $^{226}Ra$, $^{232}Th$ and $^{40}K$ in soil samples from the oil fields is 29.61± 3.03, 17.41± 1.64 and 262.63± 9.73 Bqkg$^{-1}$ respectively and 19.11± 2.35, 21.26±1.41 and 224.26±11.75 Bqkg$^{-1}$ respectively for samples from host communities. The hazard indices and excess lifetime cancer risk were estimated using standard analytical method with mean values obtained for annual gonadal equivalent dose, annual effective dose equivalent (outdoor and indoor), hazard index (external and internal), excess lifetime cancer risk, and representative gamma index which were respectively 218.49 mSvyr$^{-1}$, 39.45µSvyr$^{-1}$, 157.81µSvyr$^{-1}$, 0.18, 0.232, 0.138 x 10$^{-3}$ and 0.49 for the host community and, 246.73 mSvyr$^{-1}$, 43.47µSvyr$^{-1}$, 173.9 µSvyr$^{-1}$, 0.202, 0.282, 0.152 x 10$^{-3}$ and 0.547 for oilfield soil samples. The values when compared with their corresponding world permissible values were found to be below the standard limit for such environment. The soil from the study area provided no excessive exposure for the inhabitants and can be used as building material without posing any radiological threat or harm to the public users.*

**Keywords:** Excess lifetime cancer risk, Hazard indices, Onelga, Radionuclide

## INTRODUCTION

Natural radioactivity is widespread in the earth environment and it exists in various geological formations such as earth crust, rocks, soils, plants, water and air. Natural radioactive concentration mainly depends on geological and geographical condition and appears at different level in soils of each different geological region (UNSCEAR, 2000). Soil radionuclide activity concentration is one of the main determinants of the natural background radiation. When rocks are disintegrated through natural process, radio nuclides are carried to soil by rain and flows (Taskin et al., 2009). In addition to the natural sources, soil radioactivity is also affected by man-made activities.

During exploration and extraction processes of crude oil, various operational practices contribute to or induce NORM occurrence, namely remote sensing methods of mapping and explosives associated with seismic exploration, drilling equipment and activities and down – the –hole geophysical logging methods. In some instances, radioactive marker bullets are employed as an aid in relative depth determinations. The gamma ray log is used to locate the bullets after casing has been set. Radioactive tracers are also used in evaluating the effectiveness of well cementing and underground water and crude oil flow direction for the purpose of correlation (Ajayi et al., 2009). In some cases, various amounts of radioisotopes are injected with the secondary recovery flooding fluids to facilitate flow. The wastes originated from these activities are released into the environment, polluting the soil and water bodies. Hence an environmental management of the highest quality is needed to reduce the resultant safety problems for both the environment and population. So far under Nigerian legislation, there were no radiological controls on the operation of these industries or restrictions on how waste is discharged (to atmosphere, to landfill, to cellar pits etc.) which relate to radionuclide content (Avwiri and Ononugbo, 2012).

The long term exposure to radionuclide like thorium through inhalation from dust sediments has severe health effects such as chronic lung diseases and bone cancer (USEPA, 2012). Thorium causes bone weakening, cranial, leucopoenia, and necrosis of the mouth and nasal tumors. While long-term exposure to radium increases the risk of developing several diseases. Inhaled or ingested radium increases the risk of developing such diseases as lymphoma, bone cancer, and diseases that affect the formation of blood, such as leukemia and aplastic anemia. These effects usually take years to develop. External exposure to radium's gamma radiation increases the risk of cancer to varying degrees in all tissues and organs. However, the greatest health risk from radium is from exposure to its radioactive decay product radon. Other diseases caused by radioactivity exposure include lung cancer, cancer of the pancreas, bone cancer risks, cataracts, sterility, atrophy of the kidney and leukemia (Taskin et al., 2009).

The knowledge of natural radioactivity present in soil enables one to assess any possible radiological hazard to mankind by uses of such material. Hence, the aim of this study is to estimate the radioactivity concentrations as well as the environmental outdoor (observed) gamma dose rates. The absorbed dose rate, the annual effective dose equivalent (outdoor), annual effective dose equivalent (indoor), internal and external hazard indices; annual gonadal equivalent dose, excess lifetime cancer risk and representative gamma index are also calculated.

## STUDY AREA

Ogba/Egbema/Ndoni Local Government Area is situated approximately between latitudes $5^0$13’22’’N and $6^0$33’42’’E of the North Western quadrant of Rivers State of Nigeria. The area is one of the highest producing oil and gas onshore of the Niger Delta. ONELGA has over 900 oil wells with over twelve active oilfields and playing host to two multinational companies viz: Nigeria Agip Oil Company (NAOC) and Total Fina Elf. They are within Oil Mining License (OML) 58 (Total Fina Elf) and Oil Mining License (OML) 61 (NAOC). The study area is semi-urban and can be considered as brown field because of oil and gas activities coupled with intense farming practice.

About 57% of ONELGA communities reside on the river banks leaving the rest on the hinterland connected to one another through a network of roads making transportation and communications not too difficult (Avwiri and Ononugbo, 2012). ONELGA is bounded on the North by Ogbaru Local Government Area of Anambra State; on the North East by Oguta and Ohaji/Egbema LGAs of Imo State; on the West by Sagbama/Yenegoa LGAs of Bayelsa State and Ndokwa-East LGA of Delta State; on the South by Ahoada-West LGA of Rivers State as shown in Figure 1 below. It is located in the Eastern Bank of the River Niger and in the heart of the Niger Delta region. ONELGA has topography of flat plains netted in a web of rivers. Spatially, the area covers an area of approximately 920 square kilometers in the northern part of the Niger Delta region located within the River Niger flood plains (Avwiri and Ononugbo, 2012).

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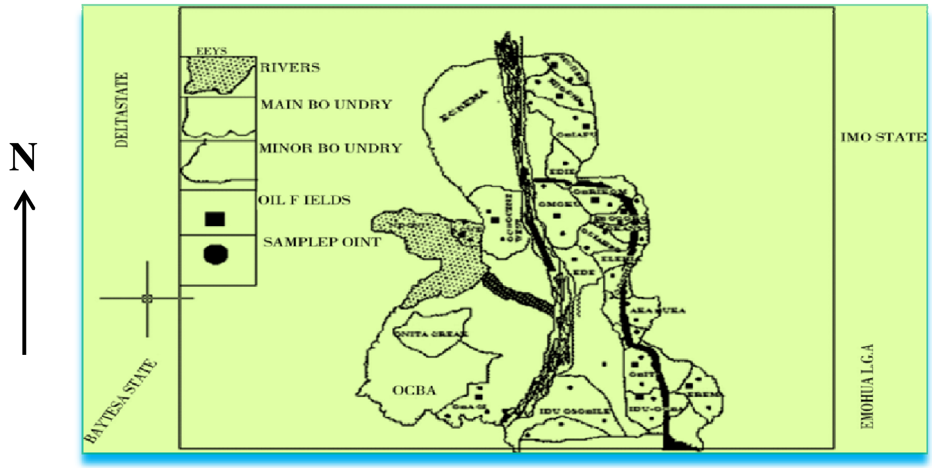


Figure 1. Sketch of the ONELGA Oil Fields Showing Sampling Areas

## METHODOLOGY

### Sample Collection and Preparation

Twelve samples of soil were collected from the twelve oil fields and their host communities and three samples from non-oil bearing community as control sample. The bulk soil (stones, vegetation's and organic debris removed) samples were collected in undisturbed, uncultivated grass covered level areas within the oil fields and the host communities (Senthikumar et al. 2010; Siegesmond et al. 2011). Each soil sample was collected in a black polythene bag within a depth of 0-15cm which represents the soil depth variation with the purpose of the soil permeability to oil spill and gaseous particle settlement depth. The samples were collected using a steel hand geological auger, which was cleaned with acid, detergent and rinsed with tap water. Samples were collected in new aluminum foil labeled and placed in black polythene bags. Sample preparation procedures have been reported elsewhere (Zarie and Al mugren 2010; Agbalagba and Onoja 2011; Agbalagba et al. 2012).

**Table 1. Activity concentration of radio nuclides in Host communities soil** samples

| *S/N* | *Oil fields* | *$^{226}Ra$ $Bqkg^{-1}$* | *$^{232}Th$ $Bqkg^{-1}$* | *$^{40}K$ $Bqkg^{-1}$* |
|---|---|---|---|---|
| 1 | Ebocha | 10.25±2.41 | 7.42±1.08 | 261.11±12.8 |
| 2 | Mgbede | 24.37±3.01 | 16.32±2.30 | 178.04±12.3 |
| 3 | Obiafu | 9.24±1.42 | 20.31±2.75 | 194.51±10.2 |
| 4 | Obrikom | 8.62±1.06 | 23.14±2.13 | 186.32±9.96 |
| 5 | Ebegoro | 41.23±4.60 | 24.41±2.24 | 421.31±17.0 |
| 6 | Omoku | 17.38±2.02 | 29.47±3.42 | 209.86±11.2 |
| 7 | Erema | 33.46±3.30 | 19.6±2.15 | 482.79±18.2 |
| 8 | Idu-Ogba | 10.1±1.32 | 17.75±2.04 | 92.42±7.23 |
| 9 | Obagi | 14.64±1.79 | 18.37±1.97 | 144.2±6.92 |
| 10 | Ogbogene | 15.62±1.67 | 18.22±1.56 | 163.24±10.5 |
| 11 | Odugiri | 20.74±3.28 | 29.83±3.21 | 108.43±9.62 |
| 12 | Agwe | 24.27±2.36 | 30.31±3.65 | 248.92±15.1 |
| *Mean Values* | | *19.16±2.35* | *21.26±1.41* | *224.26±11.75* |

**Table 2. Activity concentration of radio nuclides in Oil fields soil samples**

| *S/N* | *Oil fields* | *$^{226}Ra$ $BqKg^{-1}$* | *$^{232}Th$ $BqKg^{-1}$* | *$^{40}K$ $BqKg^{-1}$* |
|---|---|---|---|---|
| 1 | Ebocha | 17.01±3.12 | 11.42±1.40 | 268.14±10.36 |
| 2 | Mgbede | 22.64±2.93 | 9.72±1.08 | 188.29±9.32 |
| 3 | Obiafu | 27.49±3.21 | 10.68±1.72 | 395.15±10.54 |
| 4 | Obrikom | 21.34±2.15 | 31.21±2.26 | 276.23±9.54 |
| 5 | Ebegoro | 32.29±3.06 | 14.34±1.28 | 322.14±10.25 |
| 6 | Omoku | 26.65±3.42 | 20.43±1.80 | 304.27±8.44 |
| 7 | Erema | 38.92±3.25 | 12.76±1.10 | 266.29±12.21 |
| 8 | Idu-Ogba | 32.19±3.63 | 14.0±1.26 | 134.5±10.24 |
| 9 | Obagi | 27.36±2.11 | 34.13±3.92 | 278.57±8.33 |
| 10 | Ogbogene | 40.98±3.84 | 14.57±1.26 | 339.52±9.63 |
| 11 | Odugiri | 16.27±2.04 | 12.53±1.41 | 176.76±8.59 |
| 12 | Agwe | 52.19±3.62 | 23.17±1.20 | 201.68±9.24 |
| *Mean Values* | | *29.61±3.03* | *17.41±1.64* | *262.63±9.73* |

***Sample Analysis***

The samples were analyzed using a thallium activated Canberra vertical high purity 3”x 3” Sodium Iodide [NaI (TI)] detector connected to ORTEC 456 amplifier. The detector was connected to a computer program MAESTRO window that matched gamma energies to a library of possible isotopes. The cylindrical plastic containers holding the samples were put to sit on the high geometry 7.6cm x 7.6cm NaI (TI) detector. High level shielding against the environmental background radiation was achieved by counting in the Canberra 100mm thick lead castle. The $^{232}$Th concentration was determined from the average concentrations of $^{212}$Pb (238.6 keV) and $^{228}$Ac (911.1keV) in the samples, and that of $^{226}$Ra was determined from the average concentrations of $^{214}$Pb (351.9 keV) and $^{214}$Bi (609.3 and 1764.5 keV) decay products 1461keV for $^{40}$K (El-Taher., 2010).

The energy resolution of the detector using Cs-137 from International Atomic Energy agency (IAEA) is 8% at 662keV Cs-137 line, while the activity of the standard at the time of calibration is 25.37KBq. The background spectrum measured under the same conditions for both the standard and sample measurements, were used to correct the calculated sample activities concentration in accordance with (Arogunjo, et.al. 2004). The activity concentration (C) in Bqkg$^{-1}$ of the radio nuclides in the samples was calculated after decay correction using the expression:

$$C_s\ (Bqkg^{-1}) = \frac{C_a}{\varepsilon_\gamma \times M_s \times t_c \times P_\gamma} \ldots\ldots. (1)$$

Where $C_s$ = Sample concentration, $C_a$ = net peak area of a peak at energy, $\varepsilon_\gamma$ = Efficiency of the detector for a γ-energy of interest, $M_s$ = Sample mass, $t_c$= total counting time, $P_\gamma$ is the abundance of the γ-line in a radionuclide.

**Radiation Hazard Indices Calculation**

Different known radiation health hazard indices analysis is been use in radiation studies to arrive at a better and safer conclusion on the health status of a radiated or irradiated person and environment in recent studies (Avwiri *et al.,* 2012; Orgun *et. al.,* 2007; Zarie and Al Mugren, 2010; Senthilkumar *et. al.*, 2010; Agbalagba and Onoja, 2011). To assess the radiation hazards associated with the studied soil samples, the following seven quantities have been defined.

**Absorbed Dose rate (D)**

The absorbed dose rates (D) due to terrestrial gamma rays are calculated from $^{226}$Ra, $^{232}$Th and $^{40}$K concentration in soil or water assuming that other radio nuclides, such as $^{137}$Cs, $^{90}$Sr and the $^{235}$U decay series can be neglected as they contribute very little to the total dose from the environmental background. (UNSCEAR, 2000), has given the dose conversion factors for converting the activity concentrations of $^{226}$Ra, $^{232}$Th and $^{40}$K doses (nGyh$^{-1}$ per Bqkg$^{-1}$) as 0.462, 0.621 and 0.0417, respectively. The absorbed dose rate is important in radiation risk analysis since it measures the amount of radiation deposited per unit time. To avoid any somatic, epidemiological and radiological health side effect, (ICRP, 1999) recommended and consequently set the maximum permissible limit for non-radionuclide industrial worker and public as 1.0 mSvy$^{-1}$.

The gamma radiation population doses of those living in the area are given as:

$$D = 0.461C_{Ra} + 0.623C_{Th} + 0.0417C_K \ldots\ldots. (2)$$

Where, D is the dose rate in nGyh-1,$C_{Ra}$, $C_{Th}$, and $C_K$ are the concentrations of Radium, Thorium and Potassium, respectively.

**Annual Gonadal Equivalent Dose (AGED)**

The gonads, the activity bone marrow and the bone surface cells are considered as organs of interest by (UNSCEAR, 1988) because the most sensitive parts of the human body to radiation. An increase in AGED has been known to affect the bone marrow, causing destruction of the red blood cells that are then replaced by white blood cells. This situation results in a blood cancer called leukemia which is fatal. AGED for the resident of a building using a material with given activity concentration of $^{226}$Ra, $^{232}$Th and $^{40}$K is calculated using the equation below:

$$AGED\ (Sv/yr) = 3.09C_{Ra} + 4.18C_{Th} + 0.314C_K \ldots\ldots. (3)$$

Where, $C_{Ra}, C_{Th,}$ and $C_K$ are the radioactivity concentration of $^{226}$Ra, $^{232}$Th and $^{40}$K in soil samples or water samples.

**Representative Gamma Index ($I_{yr}$)**

This is used to estimate the gamma radiation hazard associated with the natural radionuclides in specific investigated samples. The representative gamma index is given as:

$$I_{yr} = C_{Ra}/150 + C_{Th}/100 + C_K/1500 \ldots\ldots. (4)$$

This gamma index is also used to correlate the annual dose rate due to the excess external gamma radiation caused by superficial materials. It is a screening tool for identifying materials that might become a health concern when used for construction (Tufail et al., 2007). Since, gamma ray can pass through any material; it can cause severe damage to the cells of human beings. Hence, an increase in the representative gamma index greater than the universal standard of unity may result in radiation risk leading to the deformation of human cells thereby causing cancer. Values of $I_{yr} \leq 1$ corresponds to an annual effective dose of less than or equal to 1mSv, while $I_{yr} \leq 0.5$ corresponds to annual effective dose less or equal to $0.3mSv$ (Turham et al., 2008).

**Annual Effective Dose Equivalent (AEDE)**

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

$$AEDE\ (Outdoor)\ (\mu\, Sv/y) = Absorbed\ dose\ D\ (nGy/h) \times 8760h\ \times 0.7\, Sv/Gy \times 0.2 \times\ 10^{-3}\ \ldots\ldots. (5)$$

$$AEDE\ (Indoor)\ (\mu\, Sv/y) = Absorbed\ dose\ D\ (nGy/h)\ \times 8760h\ \times 0.7\, Sv/Gy \times 0.8 \times\ 10^{-3}\ \ldots\ldots. (6)$$

The AEDE indoor occurs within a house whereby the radiation risks due to building materials are taken into consideration. AEDE outdoor involves a consideration of the absorbed dose emitted from radionuclides in the environment such as $^{226}$Ra, $^{232}$Th and $^{40}$K.

**Excess Lifetime Cancer Risk (ELCR)**

This deals with the probability of developing cancer over a lifetime at a given exposure level. It is presented as a value representing the number of cancers expected in a given number of people on exposure to a carcinogen at a given dose.

It is worth noting that an increase in the ELCR causes a proportionate increase in the rate at which an individual can get cancer of the breast, prostate or even blood.

Excess Lifetime cancer risk (ELCR) is given as (Taskin et. at., 2009)

$$ELCR = AEDE \times DL \times RF\ \ \ldots\ldots. (7)$$

Where, AEDE is the Annual Equivalent Dose Equivalent, DL is the average duration of life (estimated to 70 years), and RF is the Risk Factor (Sv$^{-1}$), i.e. fatal cancer risk per Sievert. For stochastic effects, ICRP uses RF as 0.05 for public (Taskin et. al., 2009). The range of ELCR is 0.071 x 10$^{-3}$ to 0.37 x 10$^{-3}$ with an average of 0.202 x 10$^{-3}$.

**Table 3. Radiation Hazard Parameters Measured in Host Community Soil**

| *S/N* | *Oil Fields* | *D (nGhr$^{-1}$)* | *AGED (mSv/yr)* | *AEDE (Outdoor) (µSv/yr)* | *AEDE (Indoor) (µSv/yr)* | $H_{ex}$ | $H_{in}$ | *ELCR x 10$^{-3}$* | $I_{yr}$ |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Ebocha | 20.23 | 144.68 | 24.81 | 99.24 | 0.111 | 0.138 | 0.087 | 0.317 |
| 2 | Mgbede | 28.82 | 199.43 | 35.34 | 141.38 | 0.166 | 0.232 | 0.124 | 0.444 |
| 3 | Obiafu | 24.99 | 174.52 | 30.65 | 122.59 | 0.144 | 0.169 | 0.107 | 0.394 |
| 4 | Obrikom | 26.12 | 181.87 | 32.03 | 128.13 | 0.151 | 0.175 | 0.112 | 0.413 |
| 5 | Ebegoro | 61.03 | 361.73 | 74.85 | 299.39 | 0.293 | 0.405 | 0.262 | 0.800 |
| 6 | Omoku | 35.08 | 242.78 | 43.02 | 172.09 | 0.204 | 0.251 | 0.151 | 0.550 |
| 7 | Erema | 47.76 | 336.92 | 58.57 | 234.29 | 0.266 | 0.357 | 0.205 | 0.741 |
| 8 | Idu-Ogba | 19.54 | 134.42 | 23.96 | 95.86 | 0.115 | 0.142 | 0.084 | 0.306 |
| 9 | Obagi | 24.19 | 167.30 | 29.67 | 118.67 | 0.140 | 0.180 | 0.104 | 0.377 |
| 10 | Ogbogene | 25.33 | 175.68 | 31.06 | 124.26 | 0.147 | 0.189 | 0.109 | 0.395 |
| 11 | Odugiri | 32.53 | 222.82 | 39.89 | 159.58 | 0.194 | 0.250 | 0.140 | 0.509 |
| 12 | Agwe | 40.42 | 279.85 | 49.57 | 198.28 | 0.234 | 0.300 | 0.173 | 0.631 |
| *Mean Values* | | *32.17* | *218.49* | *39.45* | *157.81* | *0.18* | *0.23* | *0.14* | *0.50* |

**Table 4. Radiation Hazard Parameters Measured in Oilfield Soil**

| *S/N* | *Oil Fields* | *D* *($nGhr^{-1}$)* | *AGED* *(mSv/yr)* | *AEDE* *(Outdoor)* *(µSv/yr)* | *AEDE* *(Indoor)* *(µSv/yr)* | $H_{ex}$ | $H_{in}$ | *ELCR* *$x\ 10^{-3}$* | $I_{yr}$ |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Ebocha | 26.13 | 184.49 | 32.05 | 128.18 | 0.146 | 0.192 | 0.112 | 0.406 |
| 2 | Mgbede | 24.35 | 169.71 | 29.86 | 119.45 | 0.138 | 0.199 | 0.105 | 0.374 |
| 3 | Obiafu | 35.81 | 253.66 | 43.92 | 175.67 | 0.198 | 0.272 | 0.154 | 0.554 |
| 4 | Obrikom | 40.84 | 283.13 | 50.09 | 200.34 | 0.236 | 0.293 | 0.175 | 0.639 |
| 5 | Ebegoro | 37.25 | 260.87 | 45.68 | 182.73 | 0.210 | 0.297 | 0.160 | 0.573 |
| 6 | Omoku | 37.69 | 263.29 | 46.22 | 184.89 | 0.214 | 0.286 | 0.162 | 0.585 |
| 7 | Erema | 37.01 | 257.21 | 45.39 | 181.56 | 0.210 | 0.315 | 0.159 | 0.565 |
| 8 | Idu-Ogba | 29.17 | 200.22 | 35.77 | 143.1 | 0.169 | 0.256 | 0.125 | 0.444 |
| 9 | Obagi | 45.45 | 314.68 | 55.74 | 222.96 | 0.264 | 0.338 | 0.195 | 0.709 |
| 10 | Ogbogene | 42.14 | 294.14 | 51.68 | 206.72 | 0.238 | 0.348 | 0.181 | 0.645 |
| 11 | Odugiri | 22.67 | 157.15 | 27.80 | 111.21 | 0.129 | 0.173 | 0.097 | 0.352 |
| 12 | Agwe | 46.91 | 321.44 | 57.53 | 230.12 | 0.272 | 0.413 | 0.201 | 0.714 |
| *Mean Values* | | *35.45* | *246.73* | *43.47* | *173.9* | *0.202* | *0.282* | *0.152* | *0.547* |

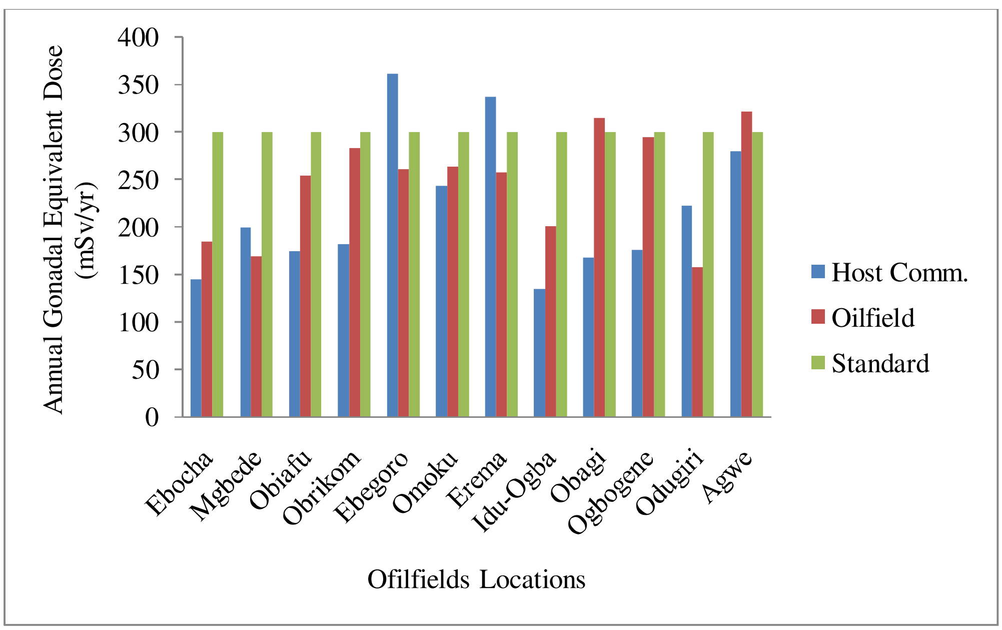


Figure 2. Annual Gonadal Equivalent Dose (AGED) in Host Communities and Oil fields compared with the UNSCEAR, 2000

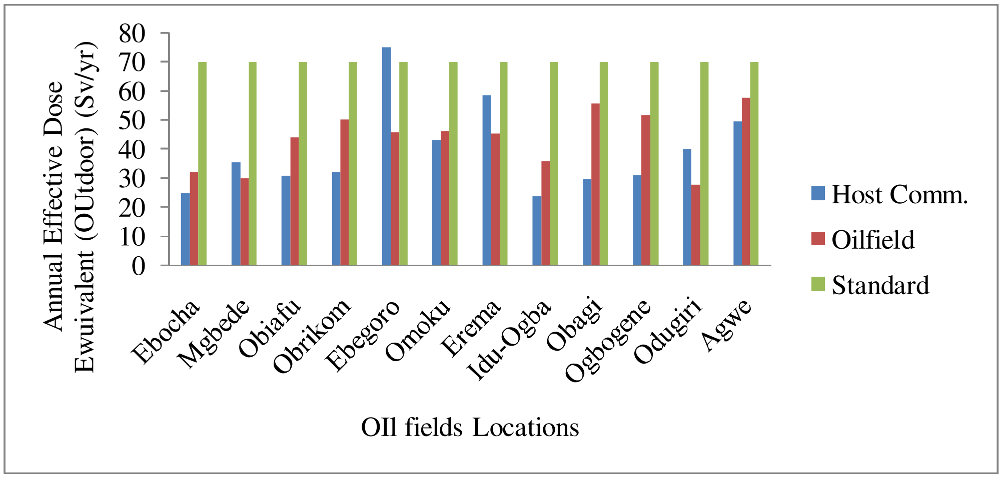


Figure 3. A comparison of the Annual Effective Dose Equivalent (Outdoor) (AEDE) in soils of oilfields and host communities with the UNSCEAR, 2000

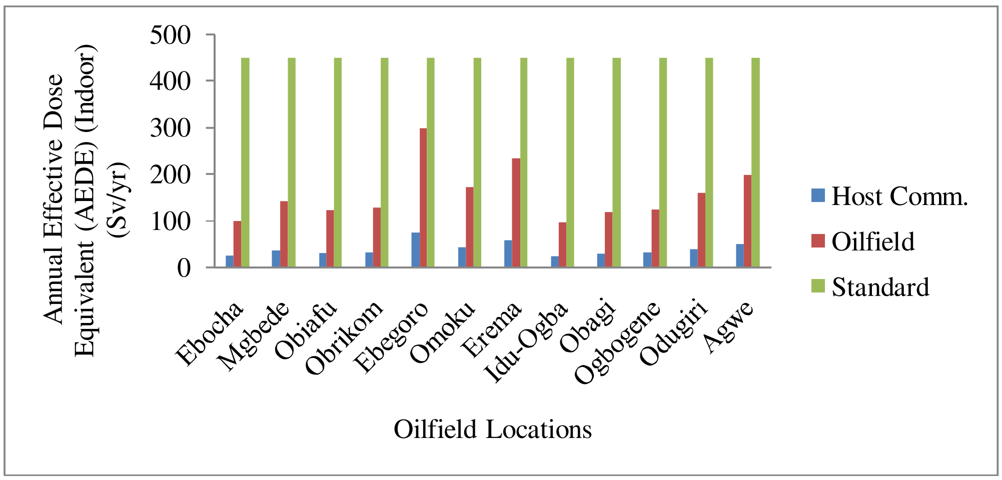


Figure 4. A comparison of the Annual Effective Dose Equivalent (Indoor) (AEDE) in soils of oilfields and host communities with the UNSCEAR, 2000

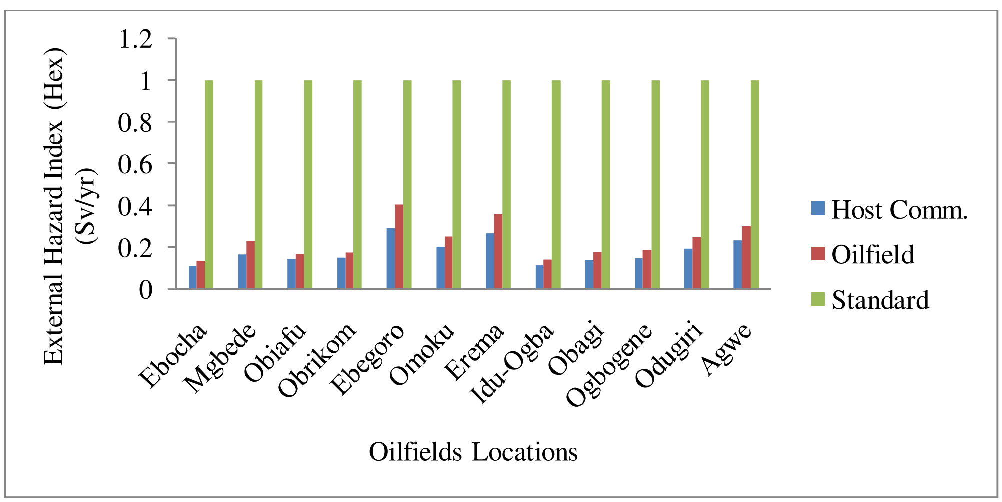


Figure 5. External Hazard Index compared with UNSCEAR, 2000

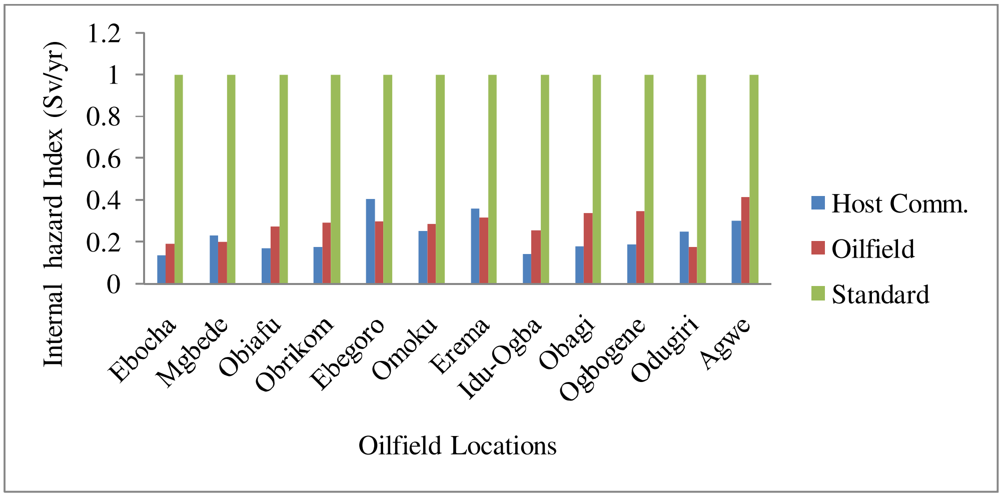


Figure 6. Internal Hazard Index compared with UNSCEAR, 2000

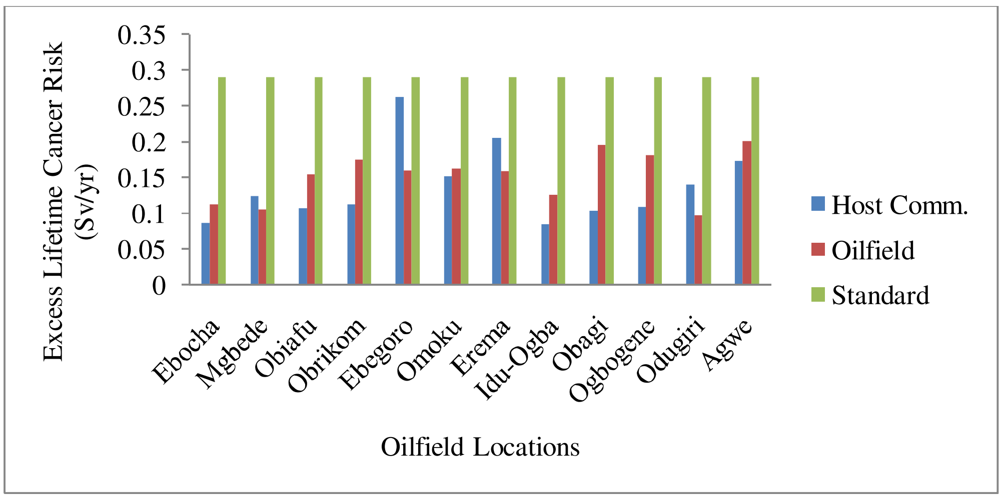


Figure 7. Excess Lifetime Cancer Risk compared with UNSCEAR, 2000

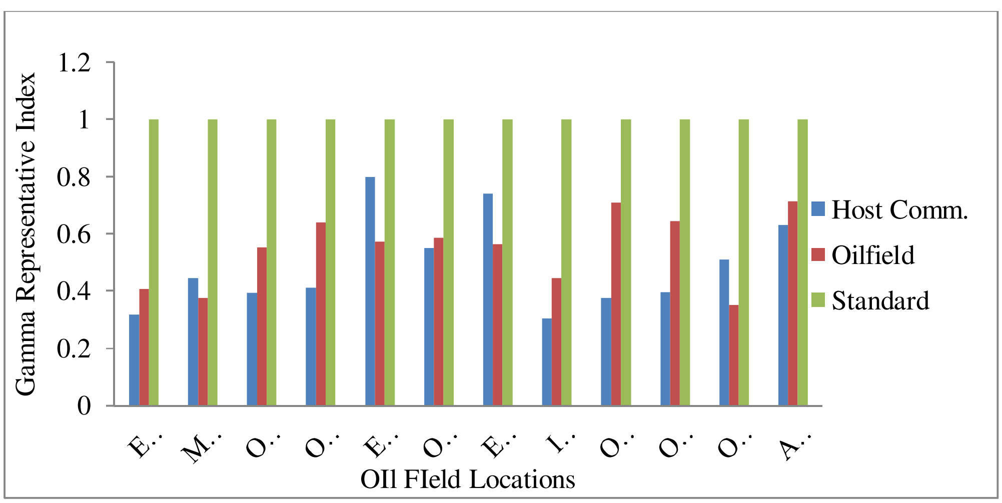


Figure 8. Gamma Representative Index compared with UNSCEAR, 2000

**External Hazard Index ($H_{ex}$)**

Many radio nuclides occur naturally in terrestrial soils and rocks and upon decay, these radionuclide produce external radiation field to which all human beings are exposed. In terms of dose, the principal primordial radio nuclides are $^{232}$Th, $^{238}$U and $^{40}$K. Thorium and Uranium head the series of radio nuclides that produce significant human exposure.

The external hazard index ($H_{ex}$) is defines as (Beretka and Mattew, 1985).

$$H_{ex} = C_{Ra}/370 + C_{Th}/259 + C_K/4810 \ldots\ldots. (8)$$

Where, $C_{Ra}$, $C_{Th}$ *and* $C_K$ are the radioactivity concentration in Bq/kg of $^{232}$Th, $^{238}$U and $^{40}$K. The value of this index must be less than unity for the radiation hazard to be negligible (Beretka and Mattew, 1985).

**Internal Hazard Index ($H_{in}$)**

The internal hazard index is given as (Beretka and Mattew, 1985)

$$H_{in} = C_{Ra}/185 + C_{Th}/259 + C_K/4810 \ldots\ldots. (9)$$

$H_{in}$ Should be less than unity for the radiation hazard to be negligible. Internal exposure to radon and its daughter products are very hazardous and can lead to respiratory diseases like asthma and cancer.

## DISCUSSION

The specific radioactivity levels together with their respective standard deviations (SD) of the natural radio nuclides obtained are presented in Tables 1 and 2. The mean values of $^{226}$Ra, $^{232}$Th and $^{40}$K are 19.16 ± 1.03 Bqkg$^{-1}$, 21.26 ± 1.41Bqkg$^{-1}$ and 224.26 ± 11.75Bqkg$^{-1}$ respectively for the soil samples from host communities 29.61± 3.03 Bqkg$^{-1}$, 17.41± 1.64 Bqkg$^{-1}$ and 262.63±9.73 Bqkg$^{-1}$ in samples from oilfields. These activity concentration values obtained in oil field and host community samples are below the world permissible value of 35.0 Bqkg$^{-1}$ for $^{226}$Ra, 30.0 Bqkg$^{-1}$ for $^{232}$Th and 400.0 Bqkg$^{-1}$ for $^{40}$K (UNSCEAR, 2000).

The relatively high values of $^{40}$K are comparable with the values reported by (Agbalagba et al., 2012, Ajayi et al., 2009, Tchokossa et al., 1999) could also be as a result of feldspar that characterize the area of study. The results obtained for the radium equivalent activity and annual gonadal dose equivalent is below the permissible values of 370 Bqkg$^{-1}$ and 300 mSvy$^{-1}$ respectively (UNSCEAR, 2000). This implies that the gonadal values may pose no threat to the bone marrow and the bone surface cells of the oil workers and community residents in the area of study. Also external hazard index, internal hazard index and representative gamma index are less than the world permissible value of unity (Avwiri and Ononugbo, 2012, Orgun et al., 2007). This is an indication that the obtained values will not pose any respiratory tract disease such as asthma and other external diseases such as erythema, skin cancer and cataracts to the users of such soil.

In addition, the present value of indoor and outdoor annual effective dose equivalent is lower than the world average values of 70µSvy-1 for outdoor and 450 µSvy$^{-1}$ for indoor (Avwiri et al., 2012). Average excess lifetime cancer hazard risk (ELCR) for all samples is less than the world average of $0.29 \times 10^{-3}$ (Taskin et al., 2009). This implies that the chances of developing cancer by oil workers and the general populace are insignificant for now but continuous accumulation may pose health

## CONCLUSION

The average specific activity concentrations of $^{226}Ra$, $^{232}Th$ and $^{40}K$ in samples of soil from oilfield and their host communities were within the world average values. The average outdoor and indoor terrestrial gamma dose rate is less than world average. The other calculated radiation parameters including the excess lifetime cancer risk are within the acceptable limit. This implies that Onelga soil can be used safely for construction of buildings. This information is important for local people utilization of the soil in their local huts construction.

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