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Gross Alpha and Gross Beta Radioactivity in Drinkable Water and Soil/Sediment around Oil Spill Sites in Delta State, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author GOA designed the study. Author MUA performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors CPO and MUA managed the analyses of the study. Author MUA managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The gross alpha and beta activity concentration in drinkable water and soil/sediment from oil spilled communities of Delta state have been carried out using calibrated MPC 2000 Protean ORTEC desktop gross alpha/beta counter. A total of 22 water samples (11 River water and 11 well water) and 22 soil/sediment (11 soil and 11 sediment) were collected in 2-litre plastic containers with about 1% air space left for thermal expansion and black polyethene bags respectively. All the samples were prepared following international standard organization (ISO) procedure. The result showed that gross alpha activity in River water ranged from 0.013±0.005 to 0.0783±0.015 Bql^{-1} while the gross beta activity concentration in River water ranged from 0.0073±0.015 to 0.0928 ±0.024 Bql^{-1}. The gross alpha and beta activity in ground (well) water ranged from 0.018±0.006 to 0.0817±0.014 Bql^{-1} and 0.0126 ±0.013 to 0.173±0.063 Bql^{-1} respectively. The mean gross alpha and beta activity in soil and sediment are 12.0±1.0 and 23.27±3.0 Bq/kg and 23.0±4.0 and 21.73± 15.0 Bq/kg respectively. The total annual effective dose estimated from both alpha and beta

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emitting radionuclides in water resources sampled, ranged between 0.007 to 0.063 $mSvy^{-1}$ in river water and 0.021 to 0.102 $mSvy^{-1}$ for well water. The annual gonadal dose resulting from gross alpha and beta activity in surface and ground water ranges from 0.019 to 0.238 $mSvy^{-1}$ and 0.037 to 0.406 $mSvy^{-1}$ respectively. The highest gonad dose of 0.238 $mSvy^{-1}$ and 0.439 $mSvy^{-1}$ was obtained in surface water (OTU_1) and ground water (OTU_2) respectively. The estimated excess lifetime cancer risks range from 0.024 x 10^{-3} to 0.220 x 10^{-3} and 0.039 x 10^{-3} to 0.358 x 10^{-3} for river and well water respectively. The result showed a significant relationship in both surface and ground water with regression values of 0.66 and 0.84 respectively. This implies that the same radionuclide is responsible for both alpha and beta activities in the water studied. The result of this study show that all the water resources sampled pose no immediate health risk to the populace though, there is little radioactive contamination of the sampled water arising from oil spillages and may be effluent discharge into the surface water. Following no threshold model, the water sampled need to be treated to remove the radionuclide in it through ion exchange technology or reverse osmosis technology before consuming to avoid long term internal exposure.

Keywords: Contamination; ground water; gonad; reverse osmosis; radiation; threshold.

1. INTRODUCTION

Inappropriate management of radioactive materials during production of goods and services, utilizing radionuclides can result in surface contamination of the environment. Such contamination could be occasional, accidental or continuous [1]. Enhanced levels of these naturally occurring radionuclides might be present in the soil as well as surface and ground water near oil and gas production facilities. The soil acts as a source of transfers of radionuclides through the food chain depending on their chemical properties and the uptake process by the roots to plants and animals [2] hence, it is the basic indicator of the radiological status of the environment. The presence of radionuclides in water poses a number of health hazards, especially when these radionuclides are deposited in the human body through drinking. Dissolved radionuclides in water emit particles (alpha and beta) and photons (gamma) which gradually expose living tissues [3,4].

Industrial activities such as extraction and processing of minerals may cause the incorporation of radionuclides into the hydrosphere through surface or ground water [5]. For groundwater (boreholes and wells), it depends on their presence and contents in lithological of solids aquifers or rocks known as geological materials particularly the Niger Delta rock types which contains radioactive elements such as Uranium, thorium and potassium and may dissolve into ground water system during water/rock –soils interaction mechanism [6].

Oil producing communities of Niger Delta region are experiencing incessant oil spillages which contaminate both the land, surface and ground water resources [7]. Petroleum is a naturally occurring liquid mineral deposited beneath the earth's surface. Its occurrence is sometimes accompanied with the presence of natural gas [8]. The oil and associated gases are generally contaminated with radionuclides within the earth's crust. These provide the source of radiation such as alpha, beta particles and gamma rays often found in the petroleum matrix [9]. Human activities such as mining, milling and processing of uranium ores and mineral sands, manufacture of fertilizers, drilling, and transportation, processing and burning of fossil fuels have raised the concentrations of naturally occurring radioactive materials in the environment [10].

Sediments have a crucial role in the aquatic environment as they accumulate and distribute radioactive contaminants in the geographic areas. Gross alpha and gross beta activity concentration in sediment /soil are defined as the total radioactivity of all alpha and beta emitters. The values of gross alpha and beta emanating from these alpha and beta emitters in soil/sediment samples depend on the geological characteristics of the area, content of mineral deposit and the type of activity in the area [1].

Consumption of ground water with elevated amounts of natural radionuclides may increase the radiotoxicity to human and internal exposure to radiation caused by the decay of the natural radionuclides taken into the body through ingestion as well as inhalation. The decay process leads to the release of several alpha and beta particles which are responsible for the total radiation dose received from natural radioactivity as well as artificial [11]. Gross alpha and beta activities are usually represented by ^{238}U series, ^{232}Th series and non-series of ^{40}K respectively [12]. Determination of gross alpha and beta activity concentration levels in groundwater and surface water are necessary for routine monitoring of radioactivity level in ground and surface water resources. This is to ensure that the reference dose level (RDL) of committed effective dose of 0.1mSvy^{-1} consumption of drinking water is not exceeded. The RDL of 0.1 mSv is equal to 10% of the dose limit for members of the public, recommended by the International Commission for Radiological Protection [13], the International Basic Safety Standard [14] and the World Health Organization [15].

The aim of this study is to evaluate the gross alpha and beta radioactivity in surface and ground water resources from five oil spilled communities of Delta state, Western Niger Delta of Nigeria, and to evaluate the annual effective dose, gonadal dose and excess lifetime cancer risk to the populace using the sampled water.

2. MATERIALS AND METHODS

2.1 Study Area

The study area lies within latitude 5°18” N and 5°86” N and longitude 5°33”E and. 6°40 E”, South-west of Niger Delta region of Nigeria [16]. This study was conducted in September, 2018. The measurements were made within the oil spill sites of Jones Creek, Opuwade Community, Okpare community, OtuJeremi community and Otor-Edo community of Delta State (Fig. 1).

2.2 Sample Collection and Preparation

A total of 44 samples (22 water and 22 soil/sediment) were collected in 2-litre plastic containers with about 1% air space left for thermal expansion and black cellophane bags was used to collect soil and sediments samples. To minimize contamination, the containers were first rinsed three times with sample water before use. Well water samples were collected manually in the early hours of the day from community wells of varying depths (5-10 m). Sample collection procedure for river/stream water collection is as reported by Avwiri and Agbalagba, [17]. Each water sample was acidified with 1 ml of concentrated HNO_3 to minimize the absorption of radioactivity into the walls of the containers [18] and evaporated to near dryness on a hot plate in a fume hood. The residue in the beaker was rinsed with 1M HNO_3 and evaporated again to near dryness. The residue was dissolved in minimum amount1M HNO_3 and transferred into a weighed 25 mm stainless steel planchet. The planchet with its content was heated until all moisture has evaporated. It was then stored in a desiccator and allowed to equilibrate with ambient

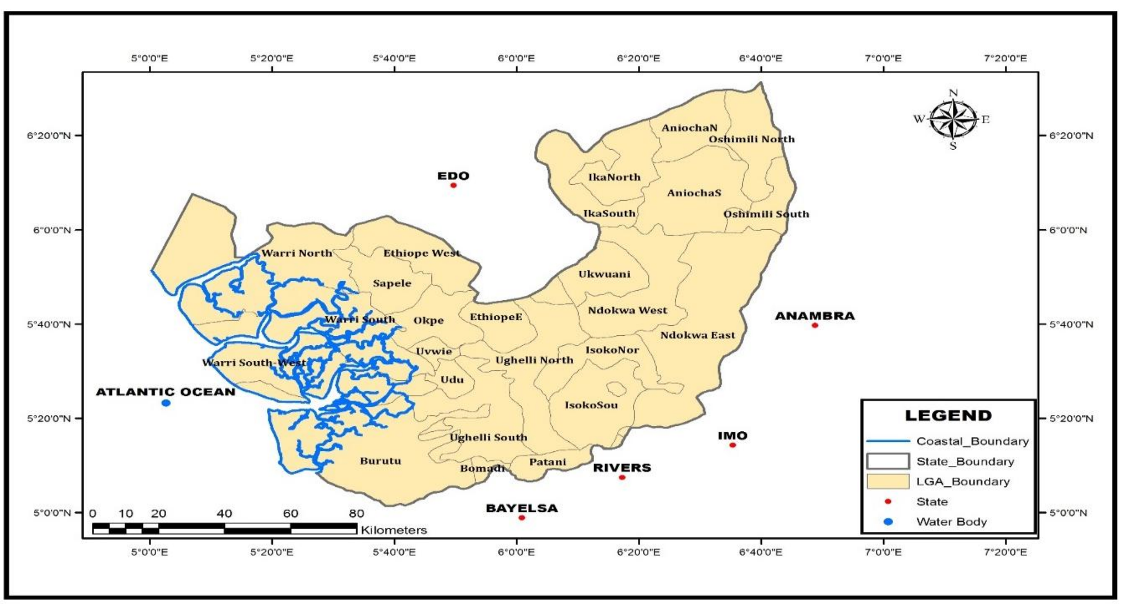

Fig. 1. Map of the study area

temperature and re-weighed. The soil/sediment samples were spread on clean stainless steel trays and air dried for 72 h. The soil/sediment samples were initial sieved to remove pebbles, grasses and any residual roots, leaves and branches of plants removed and stones. After the initial sieving the samples were dried in an electric oven at a temperature of < 80°C overnight until the moisture of the soil/sediment had dried up and crushed into fine powder. All the samples were weighed and hermetically sealed in marinelli beaker. The samples were afterwards transferred into planchet, weighed and set aside for analysis.

2.3 Counting Equipment

The samples were analyzed for gross alpha and beta activities using Protean Instrument Corporation (PIC) MPC 2000DP, USA available at the Centre for Energy Research and Training, Ahmadu Bello University, Zaria, Nigeria. This equipment was calibrated with Sr-90 a beta source and Pu-239 an alpha source [8]. This instrument had a reported calibration results of detector efficiency (alpha=87.95%; beta= 42.06%), detector background (alpha =0.30cpm; beta=0.43 cpm and detection limit (alpha= 0.21cpm; beta= 0.22cpm). Each sample was counted three times and the mean used in computing the activity.

The operational modes used for the counting were the α-only mode for the alpha counting and the β (+α) mode for the beta counting. The count rate of each sample was automatically processed by the computer using the equation 1 [16]

$$A_{(\alpha,\beta)} = B_{(\alpha,\beta)} \times 60T^{-1} \quad (1)$$

Where $A_{(\alpha,\beta)}$ is the count rate (cpm) of the alpha and beta particles, $B_{(\alpha,\beta)}$ is the raw count of alpha and beta particles, T is the counting time (2700 sec or 45 sec).

The activity of each of the samples was calculated using equation 2

$$\alpha \text{ or } \beta \text{ radioactivity (Bq/l)} = \frac{\alpha\ or\ \beta\ count\ rate\ (cpm) - BKG\ count\ rate\ (cpm)}{sample\ Efficiency\ x\ sample\ size\ x\ detector\ efficiency} \text{ x } 0.0167 \quad (2)$$

2.4 Radiation Hazard Indices Calculation in Water Samples

Standard radiation hazard indices are used to evaluate the effects of radiation on the health of people exposed to radiation and the environment the indices to be evaluated are:

2.4.1 Effective dose

Effective dose is a calculated value that takes into account the absorbed dose to all organs of the body, the relative harm level of the radiation and the sensitivity of each organ to radiation.

The annual effective dose due to intake of water was determined by averaging the individual annual committed effective doses contributed by the major alpha and beta emitters in the ^{238}U and ^{232}Th series of the naturally occurring radionuclides.

$$E_{av}\ (\alpha/\beta) = \sum_i^{R(\alpha/\beta)} A_{i(\alpha/\beta)}\ X\ DCF_{i(\alpha/\beta)}\ X\ IR \quad (3)$$

Where E_{av}. *(α /β)* is the average gross annual alpha or beta effective dose in the drinkable water, *Ai (α/β)* is the gross alpha or beta activity concentration present in the water sample and DCFi *(α/β)* is the dose conversion factor for ingestion of the specific natural radionuclides for an adult which was adopted from UNSCEAR [19], report and IR is the annual water intake by adult citizen. EPA [20] assumed a daily water intake of 2 l resulting in annual consumption rate of 730 l. Damla, Cevik, Karahan, and Kobya [21], stated that more than 50% of the annual dose from intake of water corresponds to radium (alpha emitter). This was assumed in this work since the component radionuclides in the gross alpha and beta activities could not be determined due to the limited functions of the machine used. According to Gorur, Keser, Akcay, As, and Dizman [22], the major contributors to the gross beta activities are ^{210}Pb and ^{228}Ra. For calculations, the dose conversion factors of 2.80 x10^{-4} mSvBq^{-1} for ^{226}Ra and 6.90 x 10^{-4} mSvBq^{-1} for both ^{210}Pb and ^{228}Ra, published by the WHO [23] were used.

2.4.2 Annual Gonadal Equivalent Dose (AGED)

The annual gonadal dose is a measure of the health risk to human gonads resulting from exposure to a particular level of radiation. The AGED for members of the public for a given activity is given by UNSCEAR, [24].

$$AGED = \frac{AED}{W_R\ X\ W_T} \quad (4)$$

Where AGED is the annual gonad dose, AED annual effective dose, W_R is radiation weighting factor (20 for α and 1 for β) and W_T is the tissue weighting factor which is 0.2 for gonads.

2.4.3 Excess Lifetime Cancer Risk (ELCR)

This deals with the probability of developing cancer over a lifetime at a given exposure level considering 70 years as the average duration of life for human beings. It can be calculated using equation 5 [25].

$$ELCR = AED \times DL \times RF \qquad (5)$$

Where ELCR is the excess lifetime cancer risk, AED is the annual effective dose and risk factor, for stochastic effects, ICRP [26] (recommended 0.05 Sv^{-1} for the public.

3. RESULTS AND DISCUSSION

Gross alpha and beta activity measured in surface (River) and ground (well) water samples from some selected oil spilled communities of Delta state and the gross alpha and beta activity measured in soil and sediment samples are presented in Tables 1 and 2 respectively. Table 3 presents the estimated radiological health risk from all the water samples.

Table 1 show the gross alpha and gross beta activity concentration in surface and ground water from oil spilled communities of Delta state. The result showed that gross alpha activity in River water ranged from 0.013±0.005 to 0.0783±0.015 Bql^{-1} while the gross beta activity concentration in river water ranged from 0.0073±0.015 to 0.0928 ±0.024 Bql^{-1}. This result show that the highest gross alpha and beta activity concentration are lower than the WHO reference levels of 0.5 Bql^{-1} and 1.0 Bql^{-1} for alpha and beta activities respectively. The result of gross alpha activity obtained in River water in this study is slightly lower than values obtained by Agbalagba et al. [27]. Agbalagba studied the gross alpha activity in oil field river water which showed that alpha activity varied from 0.02±0.001 Bql^{-1} in Kokori oil field to 35.1±1.1 Bl^{-1} in Uzere East and West oil spilled polluted river water with a mean value of 4.1±0.1 Bql^{-1}, while the beta activity ranges from 0.7±0.03 Bql^{-1} in

Table 1. Gross Alpha and Beta activity concentration in surface and ground water (Bq/L)

S/N	Sample ID	α-activity concentration (Bq/l)	β-activity concentration river water (Bq/l)
		River water	**River water**
1	OTU 1	0.0783±0.0156	0.0928±0.0243
2	OTU 2	0.0271±0.0081	0.0209±0.0115
3	JCK 1	0.0158±0.006	0.0198±0.009
4	JCK 2	0.0193± 0.0085	0.0578±0.0148
5	OPU 1	0.0190±0.0070	0.0328±0.0112
6	OPU 2	0.0317±0.0088	0.0331±0.0128
7	OTO1	0.0228±0.0080	0.0437±0.0129
8	OTO 2	0.0130±0.0054	0.0170±0.0080
9	OKP 1	0.0150±0.0093	0.0073±0.0149
10	OKP 2	0.0257±0.0079	0.0502±0.0126
11	Control	0.0286±0.0086	0.0343±0.0131
	Mean	**0.270**	**0.379**
		Well water	**Well water**
12	OTU 1	0.0184±0.0064	0.0145±0.0090
13	OTU 2	0.0753±0.0121	0.1727±0.0196
14	JCK 1	0.0309±0.0093	0.0126±0.0132
15	JCK 2	0.0635±0.0116	0.1261±0.0184
16	OPU 1	0.0196±0.0072	0.0338±0.0113
17	OPU 2	0.0261±0.0136	0.0382±0.0230
18	OTO1	0.0606±0.0115	0.0611±0.0164
19	OTO 2	0.0149±0.0058	0.0312±0.0093
20	OKP 1	0.0817±0.0140	0.1597±0.0225
21	OKP 2	0.0433±0.0104	0.0696±0.0163
22	Control	0.0503±0.0112	0.0904±0.0178
	Mean	**0.439**	**0.728**
	WHO, 2008	**0.5**	**1.0**

Table 2. Gross Alpha and Beta activity concentration in soil /sediment samples from oil spill communities

S/N	Sample ID	α-activity concentration (Bq/kg)	β-activity concentration (Bq/kg)
		Soil	**Soil**
1	OTU 1	7.10±6.7	15.80±10.3
2	OTU 2	4.90±7.1	21.40±10.3
3	JCK 1	29.20±11.1	BDL
4	JCK 2	32.20± 8.0	0.00±12
5	OPU 1	4.20±9.6	121.10±19.0
6	OPU 2	11.3±9.2	20.10±14.4
7	OTO1	29.40±9.6	36.10±12.1
8	OTO 2	9.50±7.0	4.00±9.9
9	OKP 1	3.20±6.8	37.40±12.1
10	OKP 2	0.40±6.5	11.20±9.4
11	Control	3.90±3.0	BDL
	Mean	**12.0±1.0**	**23.27± 3.0**
		Sediment	**Sediment**
12	OTU 1	11.30±0.84	20.80±12.8
13	OTU 2	38.70±1.06	31.20±14.6
14	JCK 1	117.00±14.7	18.40±15.5
15	JCK 2	4.40±0.80	45.90±12.8
16	OPU 1	10.60±6.8	8.30±8.8
17	OPU 2	4.90±6.4	33.60±10.3
18	OTO1	29.40±9.6	36.10±12.1
19	OTO 2	16.50±7.4	14.90±9.2
20	OKP 1	19.90±10.9	27.20±16.7
21	OKP 2	8.50±9.6	BDL
22	Control	BDL	26.60±16.5
	Mean	**23.0±4.0**	**21.73±15.0**

Oweh oil field stream water to 151.2±1.8 Bql^{-1} in the Uzere East and West oil spilled polluted river water with a mean value of 40.1±0.9 Bql^{-1}. Also the gross alpha activity obtained in this study is relatively higher than 0.02 Bql^{-1} reported for Woronara river water, and is lower than the 0.154 Bql^{-1} value reported in Mills Creek in Australia [16].

The average alpha activity of this study is also lower than the average alpha activity of 0.1173 Bql^{-1} in river Kaduna [1]. However, the value is lower than the mean alpha activity value reported for Okpare Creek [17] and is also lower than the alpha activity value of 6.7±0.074 Bql^{-1} reported for Opa River irrigation farmland [28]. The relatively low alpha and beta activity may be attributed to low natural radionuclide content associated with the Niger delta underlying sedimentary rocks [29].

The gross alpha and beta activity in ground water (well) ranges from 0.018±0.006 to 0.0817±0.014 Bql^{-1} and 0.0126 ±0.013 to 0.173±0.063 Bql^{-1} respectively. This result is similar to the mean gross alpha and beta activity of 0.0064±0.0001 to 0.0182±0.0001 Bql^{-1} and 0.046±0.0001 to 0.126±0.0001 Bql^{-1} respectively obtained by Ogundare and Adekoya [1] in ground water around steel company in Delta state. The result obtained in all the oil spilled communities are lower than those recorded for ground water in Ado-Ekiti where gross alpha and beta values are 0.589±0.36 Bql^{-1} and 0.236±0.190 Bql^{-1} respectively [28]. The gross alpha activity in soil samples varies from 0.40±6.5 to 32.20±8.0 $Bqkg^{-1}$ while the gross beta activity in soil varies from BDL to 121.10±19.0 $Bqkg^{-1}$. The gross alpha activity in sediment varied from BDL to 117.0 ± 14.0 $Bqkg^{-1}$ while gross beta activity concentration in sediment varied from BDL to 45.90 ±12.8 Bqg^{-1}. The highest gross alpha and beta activity in soil of 32.2 ±8.0 and 121.10±19.0 $Bqkg^{-1}$ was obtained at JCK_2 and OPU_1 respectively while their least values of 0.40±6.5 $Bqkg^{-1}$ and BDL respectively was obtained at OKP_2 and JCK_1 respectively.

Figs. 2 and 3 shows the linear correlation of alpha and beta activity concentration in the surface and ground water sources respectively. This is to verify if the same radionuclide are responsible for alpha and beta activities in the water sampled. The result showed a significant relationship in both surface and ground water with regression values of 0.66 and 0.84 respectively. This implies that the same radionuclide is responsible for both alpha and beta activities in the water studied. Bismuth ($^{214}_{83}Bi$) emits alpha particles and beta particles

Table 3. Radiological risk parameters estimated from gross α and β activity in surface and ground water

S/N	Location	Effective dose due to α-activity	Effective dose due to β-activity	Total effective dose ($mSvy^{-1}$)	Gonadal dose due to α-activity	Gonad dose due to β-activity	Total Gonadal dose ($mSvy^{-1}$)	ELCR $x10^{-3}$
				River water				
1	OTU 1	0.016	0.047	0.063	0.004	0.234	0.238	0.220
2	OTU 2	0.006	0.011	0.016	0.001	0.053	0.054	0.056
3	JCK 1	0.003	0.010	0.013	0.0008	0.050	0.051	0.046
4	JCK 2	0.004	0.029	0.033	0.0010	0.146	0.147	0.116
5	OPU 1	0.0039	0.017	0.020	0.0010	0.083	0.084	0.071
6	OPU 2	0.006	0.017	0.023	0.0016	0.083	0.085	0.081
7	OTO1	0.005	0.022	0.027	0.0011	0.110	0.111	0.093
8	OTO 2	0.003	0.009	0.011	0.0007	0.043	0.043	0.039
9	OKP 1	0.0031	0.004	0.007	0.0008	0.018	0.019	0.024
10	OKP 2	0.005	0.025	0.031	0.0013	0.126	0.128	0.106
11	Control	0.006	0.017	0.023	0.0011	0.087	0.08	0.081
				Well water				
12	OTU 1	0.004	0.007	0.011	0.0009	0.037	0.037	0.0387
13	OTU 2	0.015	0.086	0.102	0.0038	0.435	0.439	0.358
14	JCK 1	0.006	0.006	0.013	0.0016	0.032	0.033	0.044
15	JCK 2	0.013	0.064	0.076	0.0032	0.318	0.321	0.268
16	OPU 1	0.004	0.017	0.021	0.0010	0.085	0.086	0.074
17	OPU 2	0.005	0.019	0.025	0.0013	0.096	0.097	0.086
18	OTO1	0.012	0.031	0.043	0.0030	0.154	0.157	0.151
19	OTO 2	0.003	0.016	0.019	0.0007	0.079	0.079	0.066
20	OKP 1	0.017	0.080	0.097	0.0041	0.402	0.406	0.339
21	OKP 2	0.009	0.035	0.044	0.0022	0.175	0.178	0.154
22	Control	0.0102	0.046	0.056	0.0025	0.226	0.230	0.195

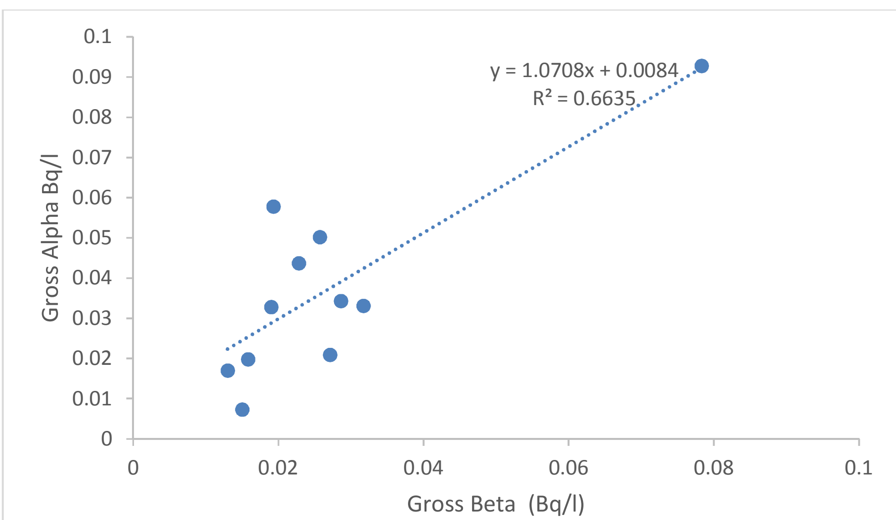

Fig. 2. Correlation between gross alpha and gross beta in River water

which implies that these water sampled might be contaminated by radioisotope Bismuth from uranium-238 decay series. Figs. 4 and 5 shows the linear correlation of gross alpha and beta in well water with gross alpha and beta in surface soil. The result showed very poor correlation with regression values of 0.0084 and 0.0082 respectively. This shows that different radionuclides are responsible for gross alpha and beta in river water and surface soil samples. Also Figs. 6 and 7 shows the linear correlation of gross alpha and beta activity in river water and sediment samples respectively. The result showed insignificant relationship with regression values of 0.056 and 0.0017 respectively. The result showed that different radionuclides are responsible for gross alpha and beta in both water bodies and soil / sediment samples.

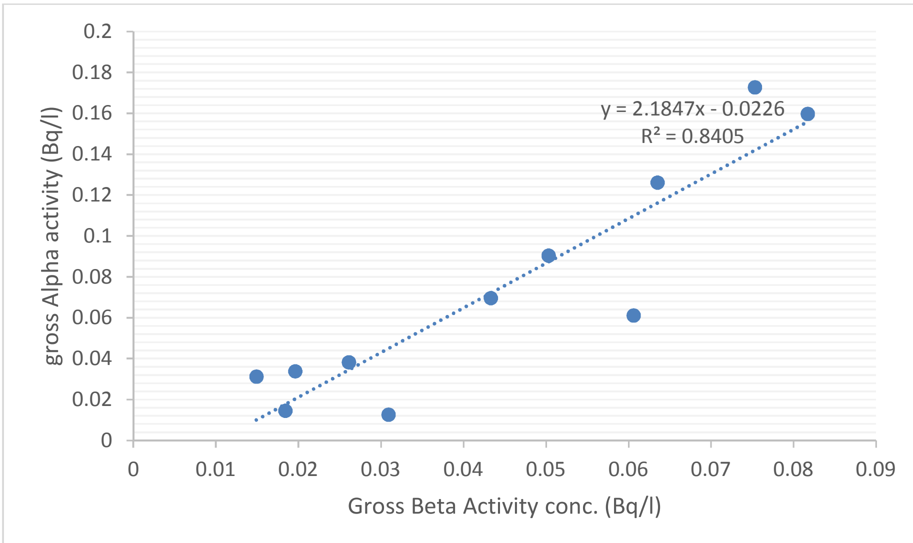

Fig. 3. Correlation between gross alpha and beta activity in ground water

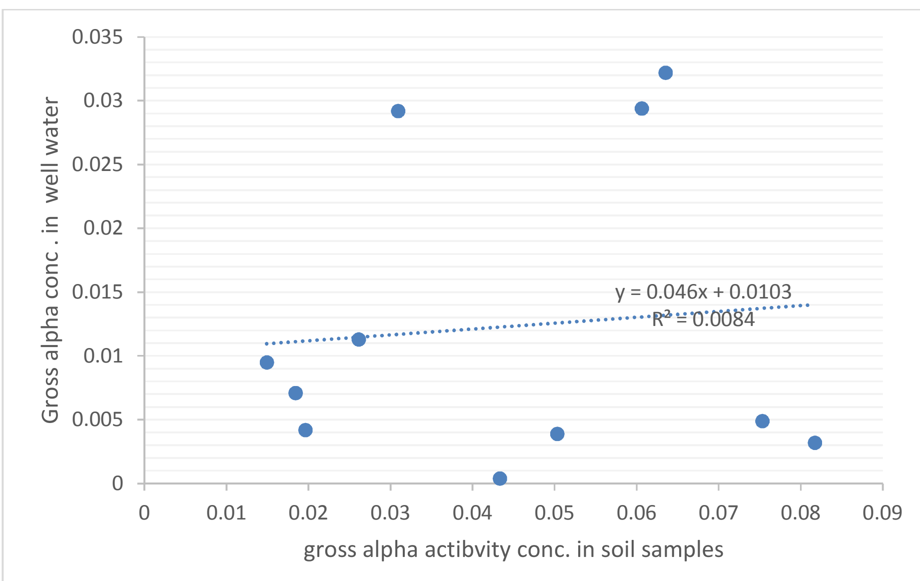

Fig. 4. Correlation of gross alpha in well water and gross alpha in soil

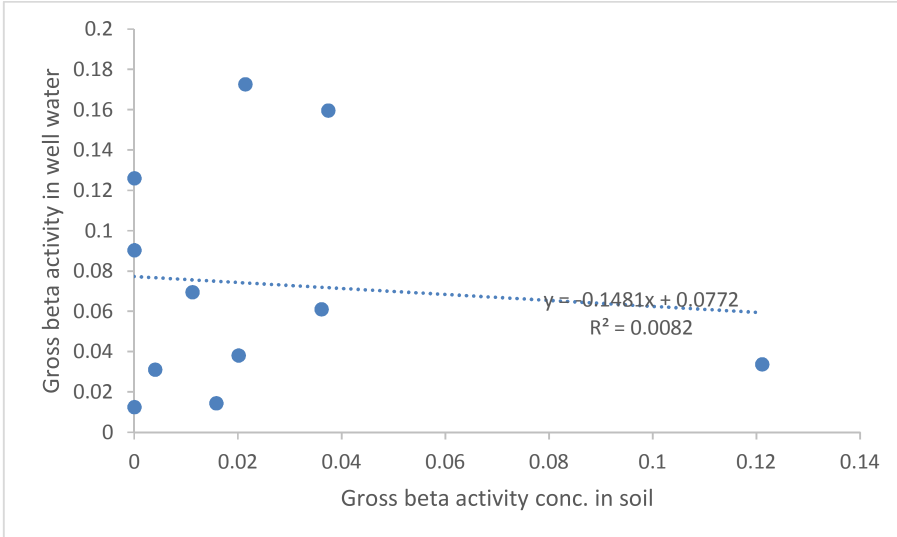

Fig. 5. Correlation of gross beta activity in well water with gross beta activity in soil

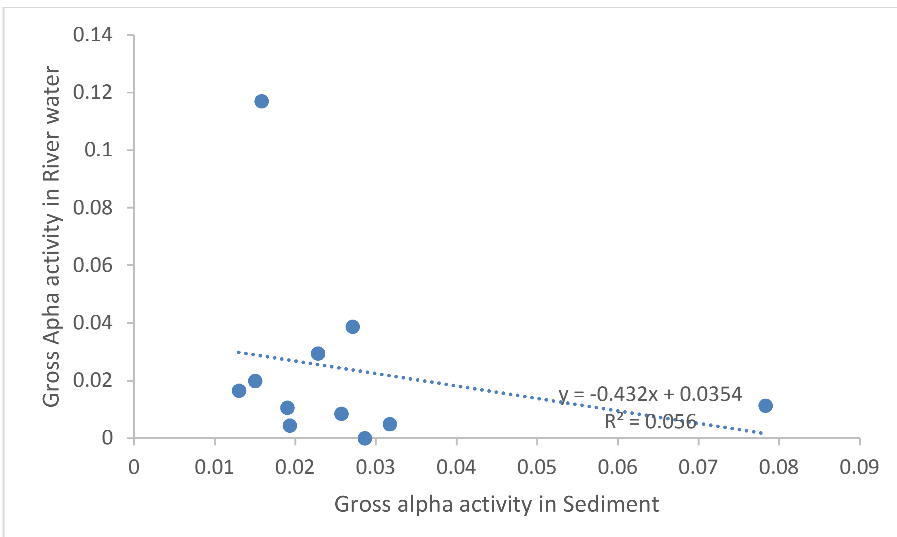

Fig. 6. Correlation of gross alpha activity in River water with gross alpha in sediment

The total annual effective dose estimated from both alpha and beta emitting radionuclides in water resources sampled, ranged between 0.007 to 0.063 $mSvy^{-1}$ in river water and 0.021 to 0.102 $mSvy^{-1}$ for well water. This result showed that some locations have values lower than the reference level of 0.1 $mSvy^{-1}$ stipulated by the World Health Organization [23]. The highest total dose of 0.063 mSv was recorded at OTU_1 (Otujeremi community) in surface water and OTU_2 in ground water samples while the least total effective dose of 0.007 mSv was recorded at Okpare community surface water and 0.011 mSv recorded at OTU_1 ground water. This result showed that greater risk is expected at OTU_1 surface water and OTU_2 ground water. This is because the oil spills was more concentrated in Otujeremi community than the other communities studied.

The annual gonadal dose resulting from gross alpha and beta activity in surface and ground water ranges from 0.019 to 0.238 $mSvy^{-1}$ and 0.037 to 0.406 $mSvy^{-1}$ respectively. The highest gonad dose of 0.238 $mSvy^{-1}$ and 0.439 $mSvy^{-1}$ was obtained in surface water (OTU_1) and

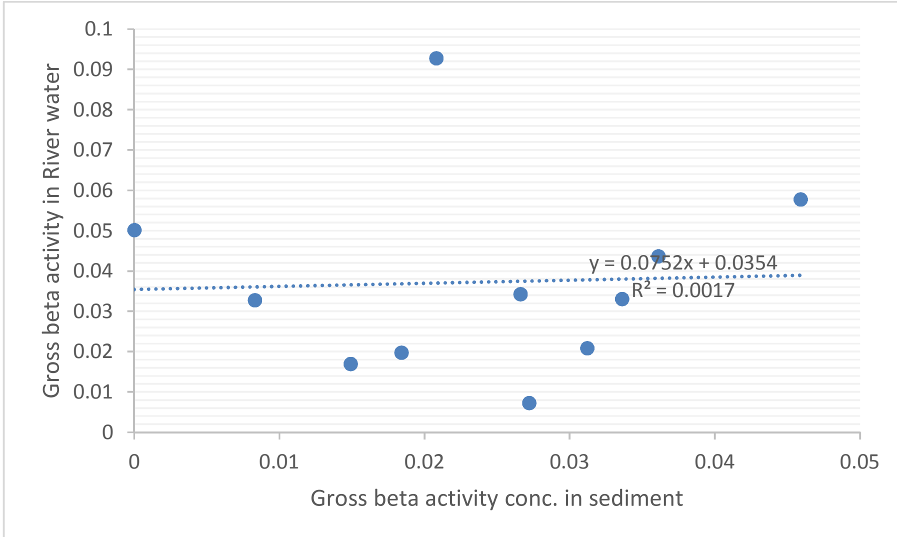

Fig. 7. Correlation of gross beta activity in River water and gross beta activity in sediment samples

ground water (OTU_2) respectively. The least gonad dose of 0.019 $mSvy^{-1}$ and 0.033 $mSvy^{-1}$ was recorded in Okpare community surface (River) water and Jones Creek community ground (Well) water. The results of gonadal doses obtained in this study are below the permissible level of 300 $mSvy^{-1}$. However, the estimated excess lifetime cancer risks range from 0.024 x 10^{-3} to 0.220 x 10^{-3} and 0.039 x 10^{-3} to 0.358 x 10^{-3} for river and well water respectively. All the values of ELCR obtained in surface (River) water are below the permissible level of 0.29 x 10-3 [30] while some sampling locations showed higher values in ground water. The results of ELCR obtained in this study are lower than the values obtained in ground water by Mangset et al. [5].

4. CONCLUSION

The gross alpha and gross beta activity concentration in surface and ground water samples collected from oil spilled communities of Delta state were measured using Protean detector. The results obtained were all within the reference level of 0.5 and 1.0 Bql^{-1}. The annual effective doses, gonadal dose and excess lifetime cancer risk estimated from the gross alpha and gross beta emitting radionuclide were all below their permissible levels of 0.1 mSv, 300 $mSvy^{-1}$ and 0.29 x 10^{-3} respectively. The result of this study show that all the water resources sampled pose no immediate health risk to the populace though, there is little radioactive contamination of the sampled water arising from oil spillages and may be effluent discharge into the surface water. Following no threshold model, the water sampled need to be treated to remove the radionuclide in it through ion exchange technology or reverse osmosis technology before consuming to avoid long term accumulated exposure.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Ogundare FO, Adekoya OI. Gross alpha and gross beta radioactivity in surface soil and drinkable water around a steel processing facility. Journal of Radiation Research and Applied Sciences. 2015;8:411-412.
2. Bunotto DM, Bueno TO. The natural radioactivity in Guarani aquifer groundwater, Brazil. Applied Radiation and Isotopes. 2008;66(10):1507-1522.
3. Alam MNC, Kamal MI, Ghose M, Islam S, Anwaruddin M. Radiological assessment of drinking water of the Chittagong region of Bangladesh. Radiation Protection Dosimetry. 1999;82(3):207-214.
4. Gruber V, Maringer FJ, Landstetter C. Radon and other natural radionuclides in drinking water in Austria: Measurement

and assessment. Applied Radiation and Isotopes. 2009;67(5):913-917.
5. Mangset WE, Ike EE, Christopher LD, Solomon AO, Mallam SP. Evaluation of the radiation hazard indices and excess lifetime cancer risk due to natural radioactivity in ground water in mining areas of Plateau state. International Journal of Engineering and Applied Sciences. 2014;5(5):9-23.
6. Marbaniang DG. Radioactivity (gross alpha and gross beta) studies of surface water collected from Domiasiat Area, west Khasi Hills District Meghalaya India. International Journal of Environmental Protection. 2011;1(4):17–21.
7. Marbaniang DG. Radioactivity (gross alpha and gross beta) studies of surface water collected from Domiasiat Area, west Khasi Hills District Meghalaya India. International Journal of Environmental Protection. 2011;1(4):17–21.
8. Avwiri GO, Osimobi JC, Ononugbo CP. Gross alpha and gross beta activity concentrations and committed effective dose due to intake of water in solid mineral producing areas of Enugu State, Nigeria. International Journal of Physics and Applications. 2016;8(1):33-43.
9. Chad-Unmourn YE. Ionizing radiation profile of the hydrocarbon belt of Nigeria in Mitsuru Ennui (Editor): Current topics in ionizing radiation research. Intec Publications, Janeza Trdine 9, 51000 Rijeka, Croatia.
ISBN 978-953-51-0196-3; 2012.
10. Pujol Li, Sanechez-Cebeza JA. Natural and artificial radioactivity in surface waters of the Ebro River Basin (Northeast Spain). Journal of Environ, Radioactivity. 2000;51:181–210.
11. Karahan G, Ozturk N, Ahmet B. Natural radioactivity in various surface waters in Istanbul, Turkey. Water Resources. 2000; 24:4367–70.
12. Eric J, Nguelem M, Danko EO, Ndontchueng MM, Schandorf C, Akiti TT, Muhulo AP, Bam EKP. The natural radioactivity in ground water from selected areas in Greater Accra beta measurements. Radiation Protection and Environment. 2013;36(1):14–19.
13. ICRP. The 1990 Recommendations of the International Commission on Radiological Protection, 21-23. Elsevier Health Sciences, USA; 1991.
14. IAEA. International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources. International Atomic Energy Agency, Vienna; 1996.
15. WHO. Guidelines for drinking water quality Third Ed., World Health Organization, Geneva, Switzerland; 2003.
16. Avwiri GO, Agbalagba EO. Survey of gross alpha and gross beta radionuclide activity in Okpare-Creek Delta State Nigeria. Journal of Applied Sciences. 2007;7(22): 3542-3546.
17. Avwiri GO, Agbalagba EO, Enyinna PI. Radioactivity concentration and distribution in River Forcados Delta state, Nigeria. Scientia Africana. 2008;7(1):128-135.
18. International Organization of Standardization. Water quantity measurement for gross alpha and beta activity in non-saline water, thick Source Method, ISO (9696 –1992 revised) and ISO (9697 –1992 revised). Geneva, Switzerland. 1992;13.
19. UNSCEAR. United Nation Scientific Committee on the Effects of Atomic Effects of Ionizing Radiation, New York; 2000.
20. US-EPA. Current Drinking Water Standard. United States Environmental Protection Agency, Washington DC, USA; 2001.
21. Damla N, Cevik U, Karahan G, Kobya AI. Gross alpha and beta activities in tap water in eastern black sea region of Turkey. Chemosphere. 2006;62(37):957-960.
22. Gorur FK, Keser R, Akcay N, As N, Dizman S. Annual effective dose and concentration levels of gross alpha and beta in Turkish market tea. Iran Journal of Radiation Research. 2011;10(2):67-72.
23. WHO. Guidelines for drinking water quality in cooperating First Addendum 1, Recommendations, 3rd edition Radiological Aspect Geneva: World Health Organization; 2008.
24. UNSCEAR, United Nationals, Sources and Effects of Atomic Radiation. Sources and effects of ionizing radiation. United Nations Scientific Committee on the effect of atomic radiation, Report to the General Assemble, Annex B Exposure from Natural Radiation Sources. United Nations, New York. 2008;44-89.
25. Ajibode MO, Avwiri GO, Agbalagba EO. Evaluation of radiation hazard indices in an oil mineral lease (Oil Block) in Delta State, Nigeria. International Journal of

Engineering and Applied Sciences. 2013; 4(2):104–121.
26. ICRP. Compendium of Dose coefficients based on ICRP publication 60. ICRP publication 119, Ann. ICRP 41(Suppl.); 2012.
27. Agbalagba Ezekiel O, Avwiri Gregory O, Chad-Umoren Yehuwdah E. Gross alpha and beta activity concentration and estimation of adults and infants dose intake in surface and ground water of ten oil fields environment in Western Niger Delta of Nigeria. Journal of Applied Science and Environmental Management. 2013;17(2):267-277.
28. Fasae KP. Effective dose due to intake of ground water in Ado-Ekiti Metropolis; The Capital City of Ekiti State, Southwestern, Nigeria. Journal of Natural Sciences Research. 2013;3(12).
29. Taiwo BA, Akalia TC. Spatial variation in groundwater geochemistry and water quality index in Port Harcourt. Rivers State, Nigeria. Scientia Africana. 2009;8:134-155.
30. Taskin H, Karavus M, Ay P, Topozoglu A, Hindiroglu S, Karahan G. Radionuclide concentrations in soil and life time cancer risk due to gamma radioactivity in Kirklareli, Turkey. Journal of Environmental Radioactivity. 2009;100:49-53.

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