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Assessment of Gamma-Radiation Levels in Selected Oil Spilled Areas in Rivers State, Nigeria

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Abstract
A prelude radiological impact assessment of oil spillage on the oil spilled environment, those saddled with the responsibility of cleaning the spilled crude and the host/nearest communities residents in Rivers State Nigeria has been examined *in-situ,* using radiation meters (Digilert 100 nuclear radiation meter) and a geographical positioning system (GPS). Readings were taken twice in a month for three months in the five different oil spilled site and one measurement taken at a control site where there is no oil spillage but within oil bearing community. The average radiation values in all the oil spilled site is 0.019±0.006mRh^{-1}, this is far above the 0.011±0.003mRh^{-1}obtained for the control and ICRP 0.013±0.005mRh^{-1} world background levels. The average equivalent dose rate obtained in all the five studied site is 1.6mSvy^{-1} while the dose rate in the control is 0.93mSvy^{-1}. The results showed that all the oil spilled sites yearly equivalent dose rate exceeded the 1mSvy^{-1} maximum permissible limit recommend for the public and non-nuclear industrial environment by International Council on Radiological Protection (ICRP,1999). All the oil spilled environment radiation levels exceeded the normal world average BIR level of 0.013mRh^{-1}and other reported values in similar environment. This shows that the oil spilled environment have been impacted radiologically. This will pose some long-term health side effects on the clean-up workers and residents of the host communities. Interim proactive measures are recommended while further and a detail study is ongoing.

Key words: Assessment; Radiological impact; Oil spill; Rivers State

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INTRODUCTION

The deleterious radiological health hazard *of radionuclide element* posed by human activities, especially in the production of oil and gas and its allied applications have attracted great concern and tremendous interest over the years in the field of radiation protection studies (Arogunjo *et al*., 2004a). In most of the sectors of oil and gas exploration and exploitation in the Niger Delta, radioactive materials and radiation generators are used on a large scale. These applications of radioactive materials includes industrial radiography, use of radiotracers, mapping and evaluation of geological formations and the extraction of other natural hydrocarbon resources (Arogunjo *et al*., 2004b; Avwiri *et al*., 2007). Petroleum itself is a naturally occurring liquid mineral deposited beneath the earth surface. Its occurrence is most times accompanied with the existence of natural gas. The oil, gas and associated gas are generally contaminated with radionuclides in the earth crust. These provide the source of radiation such as a, b and g often found in the petroleum matrix (Laogun *et al*., 2006). As a result of the exploration and exploitation of crude oil, the natural eco-system has been altered. This can gave rise to elevated background radiation and environmental pollution. Oil spill could be caused by vandalism or as a result of equipment failure. Background gamma radiation is emitted to the immediate environment from the natural crude oil and artificial sources during the process of oil and gas production.

This gamma rays are known to be highly penetrating and are part products of the radioactive materials containing radon which may be ingested or inhaled into the human body, e.g. during repairs and maintenance of oil facilities, clean-up of crude oil spilled site. if inhaled the dust particles and aerosols containing radon may attach themselves to the lungs where gamma rays emitted in the decay may pose increase risk lung cancer, eye cataracts and mental unbalances to personnel and host communities (Laogun *et al*., 2006; Otarigho, 2007).

The Niger Delta States particularly Rivers have been known for their great contribution to the Nigerian economy through oil and gas resources. Rivers State has gas and crude oil reserves (Osuji and Avwiri, 2005). The region has a network of flow stations, highly crises-crossed with network of pipelines carrying either oil or gas to the flow stations for onward piping to either the refineries or terminals for exportation. Excessive exposure to these ionizing radiation from gas flare, crude piping/spillage, use of radioactive elements within the fields, host communities and their immediate environments have been a growing concern to researchers. This is because, recent research findings have shown that increase in the background ionizing radiation from numerous source have various long term health hazard on workers and the general public like, cancer, mental disorder, genetic mutation etc. (Jibiri *et al*., 1999; Abison, 2001; Agbalagba *et al*., 2007).

Researches on the impact of oil and gas activities on the radiation levels of the environment have been carried out in oil and gas environment. Stanislaw and Elena (1998) studied the environmental impact of the offshore oil and gas facilities and showed that produced waters from oil and gas production contain naturally occurring radioactive elements (uranium and thorium) and their daughter progenies (^{226}Ra and ^{228}Ra). There is also a report on radiation safety study of the use of radioactive source and radiation producing machines for radiographic purpose in the Nigeria petroleum industry (Abison, 2001). Laogun *et al*. (2006) studied the variation in well-head gamma radiation levels at the Nigeria petroleum development company oil field in Ologbo and reported that the values obtained are fairly higher than the normal background level, but they are in agreement with the international Atomic Energy Agency's standard on ionizing radiation background level. .However, none of these studies or others in literature has focused primarily on crude oil spill sites.

The need for precise and accurate information on the background ionizing radiation levels of oil spilled sites and their host communities in the state and the inadequate data on background radiation levels in this kind of environment lay credence to this study. Furthermore, answer to the heighten fear of oil spill clean- up by workers in such site and closest proximity host communities health safety due to the spill make this research work most timely. The result of this study will therefore provide a baseline data for future detailed studies on the gamma radiation impacts of oil and gas spilled environment. The health implications of the obtained valued on the staff of Oil Company and residents of the host communities will also be examined.

1. EXPERIMENTAL METHOD

The study areas are in Rivers State of Nigeria, They are situated within latitudes 04^o 53' N and 05^{o}23' N and longitudes 007^o.07E and 006$^{o.}$39'E as shown in Figure 1. The geology of the study area has been widely reported (Ajayi *et al.*, 2009; Taiwo and Akalia, 2009).

An *in situ* approach of background radiation measurement was preferred and adopted to enable sample maintain their original environmental characteristics. Readings were taken at (vandalized and equipment failure) oil spilled spots of Mgbede, Aluu, Agbada, Igwurita, and Obigbo communities in Ogba/Egbema, Obio/Akpor and Obigbo oil and gas field and a control site where there is no history of oil spill but within oil exploitation field. A well calibrated digilert 50 nuclear radiation monitoring meter (S.E International, Inc. Summer town, USA) containing a Geiger Muller tube capable of detecting a, b g and x-rays within the temperature range of -10 ^{o}C to 50^{o}C was used to measure the radiation levels, while a geographical positioning system (GPS) was used to measure the precise location of sampling, Measurements were taken twice in a month in each of the oil spilled site for three consecutive months and the average values obtained.

The meter usage and readings taken was carried out as reported by (Laogun *et al*., 2006; Avwiri *et al*., 2007). Readings were obtained between 1300 and 1600 hours, since the exposure rate meters have the maximum response to environmental radiation within these hours as recommended by NCRP (1993). The count rate per minute recorded in the meter was converted to micro-roentgen per hour ($\mu R\ h^{-1}$) using the expression (Avwiri *et al*., 2007).

Count rate per minute (CMP) = 10^{-6} roentgen × Q.F. (1)

where Q.F is the quality factor, which is unity for external environment.

The equivalent dose rate was obtained as reported by Avwiri and Agbalagba, (2012); NCRP (1993).

$$1mRh^{-1}=(0.96x24x365/100)mSvy^{-1} \quad (2)$$

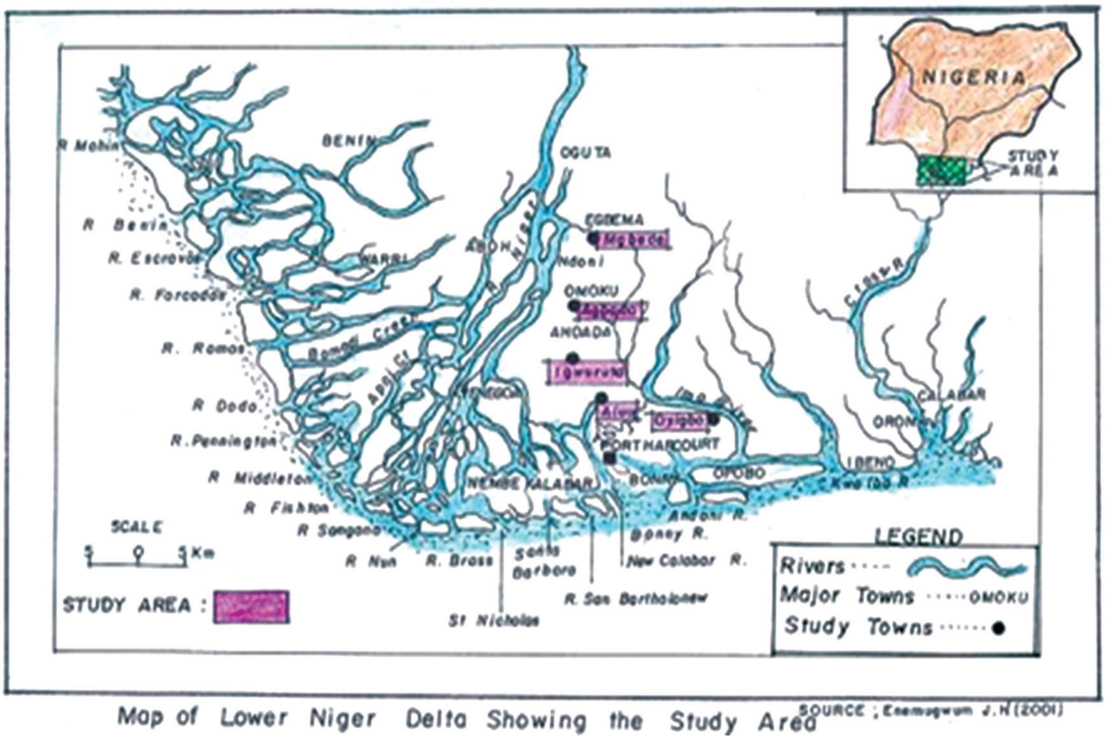

Figure 1
Map of Lower Niger Delta Showing the Study Area

2. RESULTS AND DISCUSSIONS

Table 1 shows the results of the ***in situ*** measurement carried out in the five studied oil spilled areas and one from non oil spilled environment as control. The Mgbede spill environment exposure rate ranged from 0.018mRh^{-1} to 0.020mRh^{-1}with a mean value of 0.019±0.005mRh^{-1}. The exposure rates in Omoda vandalised oil pipeline spill ranged from 0.018mRh^{-1} to 0.020mRh^{-1} with a mean value of 0.019±0.006mRh^{-1}. For Agbada 1 oil spilled site which is due to overflow of crude oil from the knockout vessel at the flow station, the exposure rate values also ranged from 0.018mRh^{-1} to 0.020mRh^{-1}with a mean value of 0.019±0.006mRh^{-1}. The exposure rates in Igwurita crude oil spilled site is not different, its values ranged from 0.018mRh^{-1} to 0.020mRh^{-1} with a mean value of 0.019±0.006mRh^{-1} while at Obigbo spilled environment, exposure rate ranged from 0.018mRh^{-1} to 0.020mRh^{-1}with a mean value of 0.019±0.007mRh^{-1}. But the exposure rate at the control (non oil impacted environment) ranged from 0.009mRh^{-1} to 0.013mRh^{-1}with a mean value of 0.011±0.003mRh^{-1}. The values obtained show a 31.6% increase above the global BIR standard of 0.013mRh^{-1} and 42.1% above the control value. Figure 2 shows the comparison of average BIR levels of the five oil spilled sites with the standard BIR level, the average values obtained in all the sites examined were far above the 0.013 mRh^{-1} global BIR levels.

Equivalent dose rate is the measure of the amount of radionuclides absorbed by the human body for a given period. 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 the public as 1.0mSvy^{-1}. Figure 3 shows the comparison of the mean oil spilled sites equivalent dose rate, the control site and ICRP, 1999 maximum permissible limit. The results revealed that the dose levels in all of the oil spilled sites exceeded the maximum permissible limit for the public. The uniformity of the average values of the exposure rate obtained in all the sites could be attributed to the crude oil spilled on the sites being from the same geological formation and may be from the same oil reservoir such that they are contaminated equally from the underlying rock. The slight variation in the reading for different day may be as a result of environmental factors. The difference observed between the exposure rates of the oil spilled sites and the control site is attributed to the impact of the crude oil spillages which have caused the elevation of the BIR levels of these areas.

The overall results showed that in all the five study sites, the exposure rates exceeded the standard background levels and the values reported by Ebong and Alagoa (1992); Avwiri and Ebeniro (1998) Avwiri and Ononugbo (2011); Elena and Gracea, (2004). But these values reported are in agreement with some previously reported results in similar environment (Arogunjo *et al*., 2004; Akpabio *et al*.; Laogun *et al*., 2006; Agbalagba *et al*., 2007), thus confirming the sources of these elevated values to the oil spills.

Table 1
Background Ionising Radiation of the Oil Spilled Area

Spill site	Geographical location	Background ionising radiation (mRh^{-1})						Average (BIR) mRh^{-1} (±SD)	Absorbed dose rate ($mSvy^{-1}$)
		DAY1	DAY2	DAY3	DAY4	DAY5	DAY6		
Mgbede	N05^{0}23\ 06.6\\ E006^{0} 39\ 44.8\	0.019	0.020	0.018	0.020	0.019	0.019	0.019±0.005	1.60±0.42
Omoda	N04^{0}56\ 37.7\\ E006^{0}56\32.1\\	0.018	0.018	0.020	0.019	0.020	0.019	0.019±0.006	1.60±0.50
Agbada 1	N04^{0}56\ 03.2\\ E006^{0}58\36.4\\	0.020	0.019	0.019	0.020	0.018	0.019	0.019±0.006	1.60±0.50
Igwurita	N04^{0}56\ 50.5\\ E007^{0}02\51.5\\	0.020	0.020	0.019	0.018	0.020	0.018	0.019±0.006	1.60±0.50
Obigbo	N04^{0}53\ 27.1\\ E007^{0}07\ 0.5\\	0.018	0.020	0.020	0.019	0.018	0.019	0.019±0.007	1.60±0.59
Control		0.013	0.009	0.013	0.011	0.010	0.009	0.011±0.003	0.93±0.25
BIR Global Standard		0.013	0.013	0.013	0.013	0.013	0.013	0.013	1.00

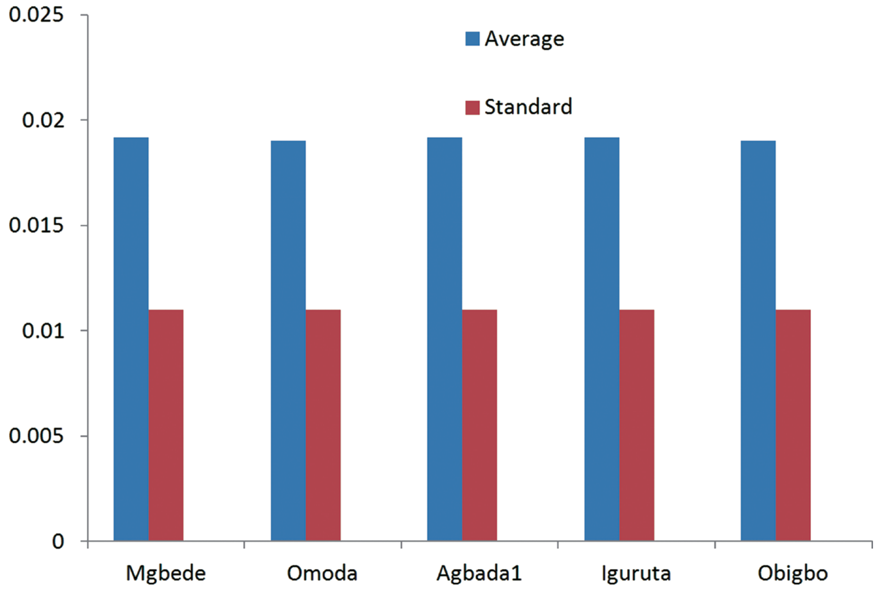

Figure 2
Comparison of Average BIR Levels with the Standard BIR Level

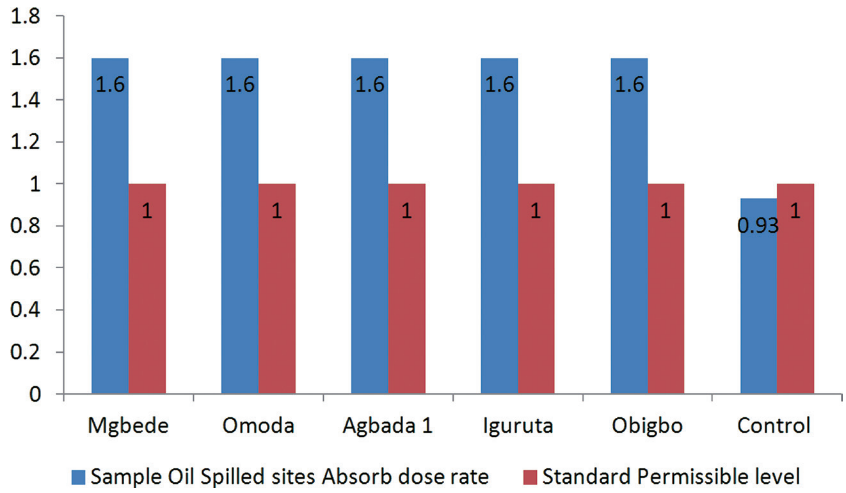

Figure 3
Comparison of the Measured Absorb Dose Rate with Standard

CONCLUSION

The assessment of the radiological impact of oil spillage on the affected environment and residents of Mgbede, Aluu, Agbada, Igwurita, and Obigbo communities areas of Rivers State has been conducted. The results (elevated background radiations) obtained showed that the soil of the affected area and the residents have been impacted negatively with radioactive elements due to the oil spillage in the study environment. These reported values may cause long-term health hazard to the oil field workers, spill management workers and residents of the host communities.

Since radiation exposure in these environment may constitutes health hazard on the long term, especially to oil spill management workers and host communities. Polluted soil/water, contaminated oil facilities, crude oil transportation challenge and oil waste materials disposal challenges must therefore be adequately recognized and addressed in the oil rich Niger Delta region.

We therefore, recommended:

- Prompt clean- up exercise should be carried out on any oil spilled environment within two days after the incident.
- Field work should be on shift basis.
- Remediation of oil spilled environment should be conducted using the best known remediation (Phyto remediation) techniques to bring the soil of the area to near natural status.
- All oil and gas installations should meet all known international and ISO standard.
- There should be a regular monitoring of radiation levels in these environments.

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