British Journal of Applied Science & Technology
4(36): 5072-5079, 2014
ISSN: 2231-0843

SCIENCEDOMAIN *international*
www.sciencedomain.org

Assessment of Background Ionization Radiation of Oil Spillage Site at Obodo Creek in Gokana L.G.A of River State, Nigeria

O. Avwiri Gregory[1], U. Nte Felix[1] and E. Esi Oghenevovwero[2*]

[1]Department of Physics, University of Port Harcourt, Choba, Rivers State, Nigeria.
[2]Department of GNS (Physics Unit), Delta State School of Marine Technology, Burutu, Delta State, Nigeria.

Authors' contributions

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

Article Information

DOI: 10.9734/BJAST/2014/12502
Editor(s):
(1) Mark Vimalan, Department of Physics, Syed Ammal Arts and Science College, India.
Reviewers:
(1) Anonymous, Obafemi Awolowo University, Nigeria.
(2) Anonymous, Korea Atomic Energy Research Institute, Korea.
Complete Peer review History: http://www.sciencedomain.org/review-history.php?iid=700&id=5&aid=6377

Original Research Article

Received 2nd July 2014
Accepted 27th July 2014
Published 7th October 2014

ABSTRACT

The assessment of background ionization radiation of oil spillage site at Obodo Creek in Gokana L.G.A of River State, Nigeria was carried out. An *In-situ* measurement was done usinga well calibrated nuclear radiation meter (Radalert-100) and a geographical positioning system (GPS). The mean background Ionization radiation values from the East, West, North and South cardinal direction of the spill site are 0.0164±0.004mR/hr, 0.0164±0.004mR/hr, 0.0171±0.006mR/hr and 0.0155±0.004mR/hr respectively while the mean Equivalent Dose Rate value are 1.3287±0.002mSv/y, 1.2278±0.001mSv/y, 1.4380±0.002mSv/y and 1.3035±0.002mSv/y. Both the background ionization radiation

**Corresponding author: E-mail: esiemmanuel@yahoo.com;*

and equivalent dose rate levels obtained values are higher than the normal world average background ionization radiation (BIR) level of 0.013mR/h and 1.0mSv/y respectively ICRP [1]. This study revealed that the crude oil spill site environment may have been impacted, but there is no immediate health implication. However, it will pose some long-term health side effects on the residents and the environment.

Keywords: Petroleum; background radiation; dose; oil spillage; equivalent dose rate; cardinal direction.

1. INTRODUCTION

Petroleum itself is a naturally occurring liquid mineral deposited beneath the earth surface. Its brought to the earth surface from the source of production (Oil wells) to the terminal through pipelines of various sizes. Its occurrence is most times accompanied with the existence of natural gas and formation water on the earth crust. The oil, gas and associated gas and formation water are generally contaminated with radionuclides in the earth crust. These provide the source of radiation such alpha, beta and gamma often found in the petroleum matrix Laogun et al. [2]. Petroleum (Crude oil) is both toxic due to its toxic chemical content and radioactive due to its radionuclide content, specifically the presence of Uranium and Thorium. These radiouclides and members of their decay chains are found in the earth's crust and therefore become incorporated into the crude oil during the process of oil drilling and production OGP [3]. These Petroleum if not properly handle can spill into the environment during production and it can affect the environment radiologically. Oil spillage is often an unintended release of crude oil into the environment as a result of human activity. Such accidents may involve a refinery, an oil storage facility, barges, oil tankers or oil pipelines. Oil spillage has been described as a major source of water and land pollution in the Niger Delta region and the increase in its frequency has been attributed to the growth of the industry and the prevalence of ageing oil pipelines. 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. A total of 10,260 oil spills is estimated to have occurred in the region between 1976 and 2007 resulting in the loss of about seven million barrels of oil. Of this quantity, 6% was spilled on land, 25% in swamps and 69% in offshore environment NREP, 2008; Chad-Umoren & Ohwekevwo [4].

The long term exposure to background radiation and radionuclide like thorium through inhalation and ingestion from dust sediments has severe health effects such as chronic lung diseases and bone cancer Jibiri et al. [5]. 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. [6].

Ononugbo et al. [7] studied the terrestrial radioactivity in the industrial areas of Ogba/Egbema/Ndoni Local Government Area (ONELGA) of Rivers state and they reported that the mean site radiation levels that were obtained ranged from 0.014±0.001 mRh^{-1} (1.183±0.060 $mSvyr^{-1}$) to 0.018±0.002 mRh^{-1} (1.183±0.085 $mSvyr^{-1}$), while the mean community radiation levels ranged from 0.014±0.001 mRh^{-1} (1.183±0.06 $mSvyr^{-1}$) to 0.017±0.001 mRh^{-1} (1.435±0.072 $mSvyr^{-1}$). The equivalent dose had an average range of 1.056 $mSvyr^{-1}$ to 2.871 $mSvyr^{-1}$, which is much lower than the International Commission on Radiological Protection recommended 20 $mSvyr^{-1}$ dose limit for radiological workers, but above the permissible level of 1 mSv/yr recommended for the general public ICRP [8]. Further analysis showed that 43sites or 72% of the sampling sites exceeded the normal background level of 0.013mRh^{-1} indicating a certain level of radiation risk for the communities hosting the facilities.

Anekwe et al. [9] studied the assessment of gamma-radiation levels in selected oil spilled areas in Rivers State, Nigeria and reported that the values obtained average radiation values 0.019±0.006mRh^{-1}, 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 value 1.6$mSvy^{-1}$ also exceeded the 1$mSvy^{-1}$maximum permissible limit recommend for the public and non-nuclear industrial environment by International Council on Radiological Protection ICRP [1]. This will pose some long-term health side effects on the clean-up workers and residents of the host communities.

Avwiri et al. [10] studied the occupational radiation profile of oil and gas facilities during production and off production periods in Ughelli, Nigeria and reported that mean radiation levels during production periods range from 15.50±1.65μR/h (0.026±0.003mSv/wk) to 19.14±3.16μR/h (0.32±0.005mS/wk) and from 13.38±1.69μR/h (0.023±0.003mSv/wk) to 16.29±2.60μR/h (0.027±0.004mSv/wk) during the off-production periods the values for both periods are all within the safe radiation limit of 0.02mSv/wk as recommended by the UNSCEAR, but the exposure rates are far above the standard background level of 13.0μR/hr indicating a measure of radiation health hazard in these locations.

Agbalagba and Meindinyo [11] studied the radiological impact of oil spilled environment: a case study of the Eriemu well 13 and 19 oil spillage in Ughelli region of delta state, Nigeria and reported that measured average location values ranged between 0.010 mRh^{-1} (0.532 mSv y^{-1}) to 0.019 mRh^{-1} (1.010mSv y^{-1}). The yearly exposure (851±0.100mSv y^{-1}) in the oil spillage area. The host communities' values ranged between 0.013±0.006mRh^{-1} (0.692±0.080 $mSvy^{-1}$) to 0.016±0.005 mRh^{-1} (0.585 mSv y^{-1}) with an average value of 0.010 mRh^{-1} (0.532 mSv y^{-1}) recorded at the control sample. The radiation levels within these oil spillage areas and the host communities were of 55% and 33.3% respectively above the normal background level of 0.013 mRh^{-1}. The average equivalent dose rate obtained was higher than the 0.478 ηSv/y normal background level but was within the safe limit of 0.05 Sv y^{-1} recommended by ICRP and NCRP. They said these values obtained will not pose any immediate radiological health hazard to the host communities and workers within this environment.

There is therefore the need to properly document the effect incessant oil spillage has had on the level of background ionizing radiation of the area. This work provides base-line data for future studies of the environment.

1.1 Study Area

The study area is situated approximately between longitude 7°12′ 59.446E and latitudes 4° 36′ 145.309N in the Gokana Local Govt Area of River State. It lies within the mangrove transmission zone of the Niger Delta and has just one main River and many creeks. The annual rainfall is about 4200mm and the mean temperature is about 38℃. The prevailing wind system is the South west and the wind speed is 7.8m/s mean. The geology of the study area has been reported earlier [12].

2. MATERIALS AND METHODS

Well calibrated portable radiation survey meter with serial number 22205 containing a Geiger Muller tube capable of detecting Alpha, Beta, Gamma and X-rays within the temperature range of -10ºC to 50ºC was used to measure the exposure level in the field. (Equipment calibration was not done by me). An in situ approach of background radiation measurement was preferred and adopted to enable samples maintain their original environmental characteristics. Readings were taken at ten (10) locations in each of the four directions of oil spill sites to spatially reflect the sites, while a geographical positioning system (GPS) was used to measure the precise location of sampling.

Readings were obtained between the hours of 1300 and 1600 hours each day, because the exposure rate meter has a maximum response to environmental radiation within these hours Louis et al. [13]. The tube of the radiation meter was raised to a height of 1.0m above the ground with its window facing first the oil spill sites and then vertically downward Avwiri et al. [14]. The detector was switched on to absorb radiation for a few seconds and the highest stable point was recorded. This was converted to annual absorbed dose rate in micro sievert per year ($mSvyr^{-1}$) [15].

The following conversion factors were used:

$$1\ \mu Sv/hr = 365 \times 24 \times 10\text{-}3\ mSv/yr$$

3. RESULTS AND DISCUSSION

Tables 1-4 shows the background ionization radiation rate and equivalent dose rate in the different directions from the oil spillage site at Obodo creek. The background ionization radiation measured at the east direction ranged from $0.011\pm0.001mRh^{-1}$ to $0.020\pm0.007mRh^{-1}$ with average value of $0.0164\pm0.004mRh^{-1}$. The background ionization radiation measured at the west direction also ranged from $0.011\pm0.001mRh^{-1}$ to $0.020\pm0.007mRh^{-1}$ with average value of $0.0146\pm0.003mRh^{-1}$.The background ionization radiation measured at the north direction ranged from $0.016\pm0.001mRh^{-1}$ to $0.020\pm0.007mRh^{-1}$ with average value of $0.017\pm0.006mRh^{-1}$. While background ionization radiation measured at the south direction ranged from $0.013\pm0.002mRh^{-1}$ to $0.018\pm0.006mRh^{-1}$ with average value of $0.0155\pm0.004mRh^{-1}$. The values obtained when compared with the global BIR standard of $0.013mRh^{-1}$ shows that they are slightly higher than the standard. Fig. 1 shows the comparison of mean BIR levels of all the four cardinal direction background ionization radiation measured spillage site with the standard BIR level. The mean values obtained in all the spill site were higher than the 0.013 mRh^{-1} global BIR levels. The mean equivalent doses in all the four cardinal directions calculated ranges from 0.9251±0.001mSv/yr to 1.6819±0.004mSv/yr. The East cardinal Direction has a minimum value of 0.9251±0.001mSv/yr at 100 meters away from the oil spill site while a maximum value of 1.6819±0.004mSv/yr is obtained at 20 meters away from the oil spill site with an mean value of 1.3287±0.002mSv/yr. In the West cardinal Direction, a minimum value of 0.9251±0.001mSv/yr is obtained at 100 meters away from the oil spill site while a maximum value of 1.6819±0.004mSv/yr was obtained at 10 meters away from the oil spill site with an mean value of 1.2278±0.001mSv/yr. The North cardinal Direction has a computed minimum value of 1.3455±0.002mSv/yr at 100 meters away from the oil spill site while a maximum value of 1.6819±0.004mSv/yr is obtained at 10 meters away from the oil spill site with an mean value of 1.4380±0.002mSv/yr. Also, the South cardinal Direction has a minimum value of 1.1773±0.001mSv/yr at 90 meters away from the oil spill site while a maximum value of 1.5139±0.003mSv/yr is obtained at 10 meters away from the oil spill site with an mean value of 1.3035±0.002mSv/yr. The computed equivalent dose rate results obtained in the four cardinal directions of the oil spill site are slightly lower than the dose limit of 1.0mSv/yr for the general public and far lower than the dose limit of 20.0mSv/yr for radiological workers as recommended by international Commission on Radiological Protection ICRP [8]. Fig. 2 shows the comparison of mean equivalent dose rate levels of all the four cardinal direction with the standard. The results obtained are in agreement with previous work reported values in similar environment by Anekwe et al. [9,11].

Table 1. East direction

Distance	Geographical location	Dose rate (mR/hr)	Equivalent dose rate (mSv/yr)
10	N04.60746º, E007.26369°	0.019±0.006	1.5978±0.003
20	N04.60752º, E007.26364°	0.020±0.007	1.6819±0.004
30	N04.60782º, E007.26351°	0.019±0.006	1.5978±0.003
40	N04.60796º, E007.26357°	0.018±0.005	1.5137±0.003
50	N04.60839º, E007.26348°	0.016±0.004	1.3455±0.002
60	N04.60841º, E007.26342°	0.014±0.003	1.1773±0.001
70	N04.60875º, E007.26335°	0.015±0.004	1.2614±0.001
80	N04.60884º, E007.26330°	0.013±0.002	1.0932±0.001
90	N04.60909º, E007.26326°	0.013±0.002	1.0932±0.001
100	N04.60931º, E007.26322°	0.011±0.001	0.9251±0.001
Mean value		0.0164±0.004	1.3287±0.002

Table 2. West direction

Distance	Geographical location	Dose rate (mR/hr)	Equivalent dose rate (mSv/yr)
10	N04.60832º, E007.26362°	0.020±0.007	1.6819±0.004
20	N04.60826º, E007.26358°	0.018±0.006	1.5139±0.003
30	N04.60814º, E007.26351°	0.019±0.006	1.5978±0.003
40	N04.60808º, E007.26346°	0.016±0.004	1.3455±0.002
50	N04.60794º, E007.26338°	0.014±0.003	1.1773±0.001
60	N04.60787º, E007.26330°	0.012±0.002	1.0092±0.001
70	N04.60775º, E007.26327°	0.013±0.002	1.0932±0.001
80	N04.60769º, E007.26320°	0.012±0.002	1.0092±0.001
90	N04.60760º, E007.26317°	0.011±0.001	0.9251±0.001
100	N04.60752º, E007.26309°	0.011±0.001	0.9251±0.001
Mean value		0.0146±0.003	1.2278±0.001

Table 3. North direction

Distance	Geographical location	Dose rate (mR/hr)	Equivalent dose rate (mSv/yr)
10	N04.56968º, E007.26288°	0.020±0.007	1.6819±0.004
20	N04.56955º, E007.26271°	0.018±0.006	1.5139±0.003
30	N04.56946º, E007.26266°	0.016±0.004	1.3455±0.002
40	N04.56940º, E007.26260°	0.017±0.006	1.4296±0.002
50	N04.56937º, E007.26253°	0.016±0.004	1.3455±0.002
60	N04.56928º, E007.26247°	0.016±0.004	1.3455±0.002
70	N04.56921º, E007.26239°	0.017±0.006	1.4296±0.002
80	N04.56913º, E007.26230°	0.018±0.006	1.5139±0.003
90	N04.56900º, E007.26224°	0.017±0.006	1.4296±0.002
100	N04.56896º, E007.26218°	0.016±0.004	1.3455±0.002
mean value		0.0171±0.006	1.4380±0.002

Table 4. South direction

Distance	Geographical location	Dose rate (mR/hr)	Equivalent dose rate (mSv/yr)
10	N04.56982º, E007.26294°	0.018±0.006	1.5139±0.003
20	N04.56994º, E007.26318°	0.016±0.004	1.3455±0.002
30	N04.57006º, E007.26327°	0.017±0.006	1.4296±0.002
40	N04.57018º, E007.26335°	0.017±0.006	1.4296±0.002
50	N04.57029º, E007.26353°	0.014±0.003	1.1773±0.001
60	N04.57034º, E007.26360°	0.016±0.004	1.3455±0.002
70	N04.57041º, E007.26377°	0.015±0.004	1.2614±0.001
80	N04.57053º, E007.26382°	0.013±0.002	1.0932±0.001
90	N04.57068º, E007.26390°	0.014±0.003	1.1773±0.001
100	N04.57077º, E007.24426°	0.015±0.004	1.2614±0.001
Meanvalue		0.0155±0.004	1.3035±0.002

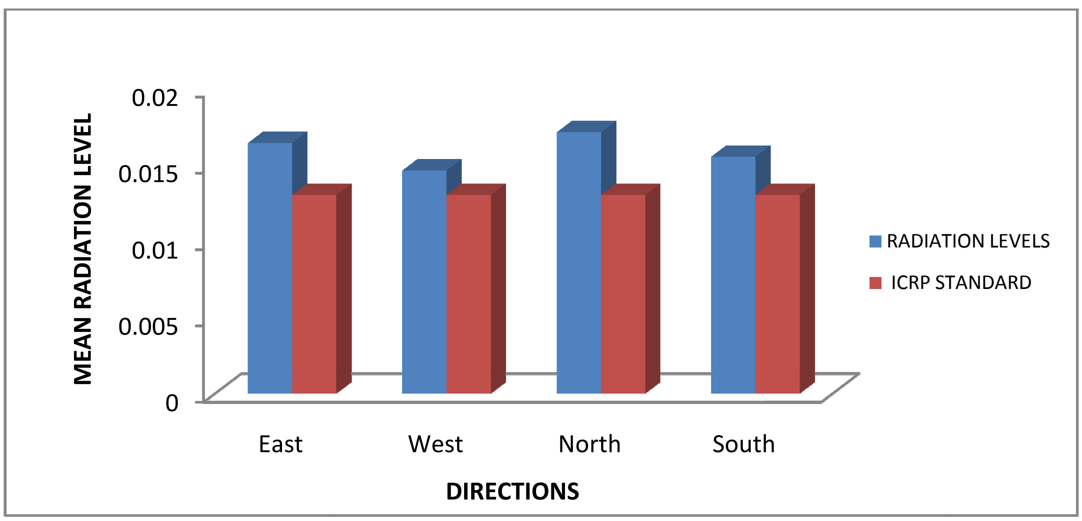

Fig. 1. Comparison of mean BIR levels with the standard BIR level

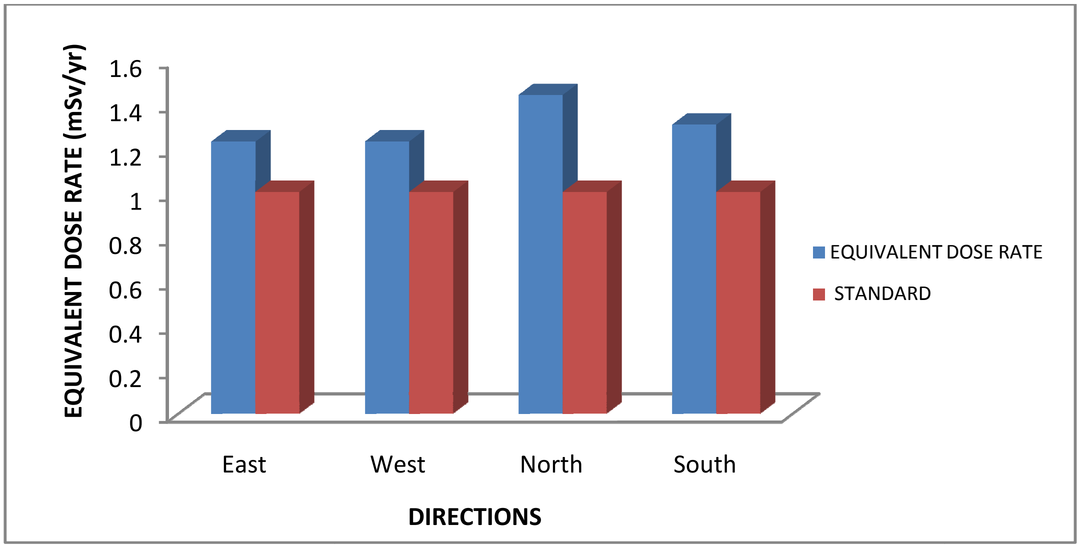

Fig. 2. Comparison of mean equivalet dose rates with the standard BIR level

4. CONCLUSION

The assessment of background ionization radiation of oil spillage site at Obodo Creek in Gokana L.G.A of River State, Nigeria has been carried out. The study revealed that the mean radiation obtained values from the four cardinal directions are higher than the normal background standard of 0.013mR/h. Also the computed equivalent dose rate results are higher than the dose limit of 1.0mSv/yr for the general public and far lower than the dose limit of 20.0mSv/yr for the general public ICRP [1]. The assessment shows that the terrestrial radiation level of the areas may have been affected by the activities of the crude oil spill in the environment. These reported values may indicate no immediate health hazards, but may cause long-term health hazard to the residents of the host community depending on the exposure rate.

We therefore recommended the following:

- Adequate clean- up exercise should be carried out on oil spilled environment.
- Remediation of oil spilled environment should be conducted using the best known 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.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. International Commission on Radiological Protection (ICRP). The 1995 – 99 recommendation of the International Commission on Radiological Protection Publication 76. Pergamon Press; 1999.

2. Laogun AA, Ajayi NO, Agaja SA. Variation in wellhead gamma radiation levels at the Nigeria Petroleum Development Company Oil Field, Ologbo Edo State, Nigeria. Nigeria Journal Physics. 2006;18(1):135-140.
3. OGP. Guidelines for the management of naturally occurring radioactive material (NORM) in the oil & gas industry, International Association of Oil & Gas Producers Report No. 412; 2008.
4. Chad-Umoren YE, Efe Ohwekevwo E. Influence of crude oil spillage on the γ-radiation status of water and soil in Ogba/Egbema/Ndoni Area, Nigeria. Energy and Environment Research. 2013;3(2). Available: http://dx.doi:10.5539/eer.v3n2p45.
5. Jibiri NO, Alausa SK, Owofolaju AE, Adeniran A. A terrestrial gamma dose rates and physical-chemical properties of farm soils from ex- tin mining locations in Jos-Plateau, Nigeria. African Journal of Environmental Science and Technology. 2011;5(12):1039-1049.
6. Taskin H, Karavus M, Ay P, Topuzoglu A, Hidiroglu S, Karahan G. Radionuclide concentration in soil and lifetime cancer risk due to the gamma radioactivity in Kirklareli, Turkey. Journal of Environmental Radioactivity. 2009;100:49-53.
7. Ononugbo CP, Avwiri GO, Chad-Umoren YE. Impact of gas exploitation on the environmental radioactivity of Ogba/Egbema/Ndoni Area, Nigeria. Energy and Environment. 2011;*22*(8):1017-1028. Available: http://dx.doi.org/10.1260/0958-305X.22.8.1017.
8. ICRP. Recommendations of International Commission of Radiological Protection. Oxford: Pergamon; 1990.
9. Anekwe UL, Avwiri GO, Agbalagba EO. Assessment of gamma-radiation levels in selected oil spilled areas in rivers state, Nigeria. Energy Science and Technology. 2013;5:(1):33-37. Available: http://dx.DOI:10.3968/j.est.1923847920130501.785.
10. Avwiri GO, Chad-Umoren YE, Enyinna PI, Agbalagba EO. Occupational radiation profile of oil and gas facilities during production and off production periods in Ughelli, Nigeria. Journal Facta Universitatis: Working and Living Environmental Protection. 2009;6(1):11-19.
11. Agbalagba OE, Meindinyo RK. Radiological impact of oil spilled environment: A case study of the Eriemu well 13 and 19 oil spillage in Ughelli region of delta state, Nigeria. Indian Journal of Science and Technology. 2010;3(9):1001-1005.
12. Taiwo BA, Akalia TC. Spatial variation in groundwater geochemistry and water quality index in Port Harcourt. Rivers State, Nigeria Scientia Africana. 2009;8(1):134-155.
13. Louis AE, Etuk ES, Essian K. Environmental radioactive levels in Ikot Ekpene Nigeria, Nig. J. Space Res. 2005;1:80-87.
14. Avwiri GO, Agbalagba EO, Enyinna PI. Terrestrial radiation around oil and gas facilities in Ughelli Nigeria. Asian Network for Science Information. Journal Applied Science. 2007;7(11):1543-1546.
15. Avwiri GO, Agbalagba EO. Studies on the radiological impact of oil and gas activities in oil mineral lease 30 (OML3) oil fields in Delta State, Nigeria. Journal Petroleum Environmenetal Biotechnology. 2012;3(2):1- 8.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history.php?iid=700&id=5&aid=6377