Advances in Physics Theories and Applications
ISSN 2224-719X (Paper) ISSN 2225-0638 (Online)
Vol.22, 2013


# Radiometric Survey of Aluu Landfill, In Rivers State, Nigeria

[1]Gregory O. Avwiri, [2*]Jafaru M. Egieya, [3]Chinyere P. Ononugbo

1. Department of Physics, Faculty of Science, University of Port Harcourt, Choba, Rivers State, Nigeria
2. Centre for Nuclear Energy Studies (CNES), University of Port Harcourt, Choba, Rivers State, Nigeria
3. Department of Physics, Federal College of Education (Techn.), Omoku , Rivers State, Nigeria.

*Email of corresponding author: jegieya@gmail.com

**Abstract**

A key component of the Millennium Development Goals is a call to halve by the year 2015 the proportion of persons without sustainable access to safe drinking water and basic sanitation in developing nations. This paper reports a study of the terrestrial radioactivity around Aluu landfill in Obiakpor Local Government Area of Rivers State, Nigeria. Measurements were carried out in the North, South, East and West directions of the Aluu landfill. An in- situ measurement was done using two well calibrated nuclear radiation meters (Radalert-100 and Digilert-50) and a geographical positioning system (GPS). Ten readings were taken in each direction of the landfill at intervals of ten (10) meters away from the landfill making a total of forty (40) sampling points. The mean site radiation levels all the four cardinal points ranges from 0.0123±0.0026 mR/hr (1.034mSv/y) to 0.0151± 0.0012mR/h (1.270mSv/y). The equivalent dose has an average value range of 1.001mSv/y to 1.270mSv/y which is slightly above the recommended dose limit of 1.0mSv/y for the general public. Comparison of the measured radiation level of site locations with the normal background levels show 21 locations representing 53% of the sampled area exceed the normal background level of 0.013mR/h. This study indicates that there is no immediate radiological health hazard for the general public, however there may be long-term health challenges.

**Keywords:** Assessment, Dose equivalent, Landfill, Millennium, Radalert, Digilert.

## 1. Introduction

The arbitrary and indiscriminate dumping of wastes in landfills has posed a grave health risk to the populace. The indiscriminate waste dumps cause soil pollution and underground water pollution which can lead to unsustainable and wasteful utilization of resources giving rise to land degradation and threat to human health (Odunaike et al, 2008). It was revealed that staple food stuffs consumed in Nigeria contain traces of radionuclide (Jibiri et al., 2007) and as a result of this, the refuse landfills are liable recipients of any such failure in containment of radioactive materials (Farai et al., 2007). It has also been established that vegetation and environmental fields in Nigeria contain traces of radionuclides (Akinloye and Olomo, 2005). The deleterious radiological health hazards posed by human activities, especially in the production of energy, research, medical application as well as oil and gas extraction and production have attracted great concern and tremendous interest over the years in the field of radiation protection due to the enormous amounts of waste generated which have large constituents of radionuclides embedded in them (Arogunjo et. al., 2004).

Landfills as defined by the Merriam Webster dictionary are “Systems of trash and garbage disposals in which the waste is buried between layers of earth to build-up a low-lying land – called also sanitary landfill. They may also be described as holes in the ground where wastes are placed, perhaps in the site of a disused quarry or pit, or they may be purposefully excavated (Avwiri et. al. 2011). Landfills contain a mixture of wastes, some of which may be soluble, toxic and reactive during decomposition. Landfill is therefore likely to remain a relevant source of groundwater contamination for the foreseeable future.

The need for precise and accurate information on the background ionizing radiation levels of landfills and the inadequate data on background radiation levels in this kind of environment lay credence to this study. The result of this study will therefore provide a baseline data for future detailed studies on the gamma radiation impacts of landfill environment and also estimate the radiological burden on the populace and environment.

## 2. Materials And Methods

*2.1 Study Area:* The Aluu landfill has coordinates of latitude $04^0 55^' 14.8''$ North and longitude $006^0 55' 07.7''$ East with an elevation of 15.2m within Obio/Akpor Local Government of Port Harcourt Metropolis in Rivers State, Nigeria. It has dimensions of about 160 m by 35 m and it is accessible through the Aluu tarred road. The site is surrounded by a network of privately owned residential houses, with a church 150 m away from the landfill. Furthermore, the landfill is approximately 3km away from the University of Port Harcourt and about

800 m from the University Demonstration Secondary School (UDSS). Aluu landfill is characterized by alternate seasons of wet and dry (Iloeje, 1972), with total annual rainfall of about 240 cm, relative humidity of over 90% and average annual temperature of 27$^0$C (Udom et al., 2004).

An *in situ* approach of background radiation measurement was preferred and adopted to enable sample maintain their original environmental characteristics. Readings were taken in the North, South, East and West directions of Aluu landfill at intervals of 10 meters to a maximum of 100 meters in all directions. A well calibrated Digilert- 50 and digilert-100 nuclear radiation monitoring meter (S.E. International, Inc. Summer Town, USA) containing a Geiger Muller tube capable of detecting Alpha, Beta, Gamma 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. Readings were obtained between the hours of 1300 and 1600 hours because the exposure rate meter has a maximum response to environmental radiation within these hours (Louis et al, 2005). Three readings were taken at intervals of 5 minutes at each of the selected sites and average calculated. The tube of the radiation meter was raised to a height of 1,0m above the ground with its window facing first the landfill and then vertically downward (Avwiri *et al*., 2007). The instrument was calibrated to read accurately in Roentgens with a 137Cs source of a specific energy.

To estimate the whole body equivalent dose rate, we use the National Council on Radiation Protection and Measurement (NCRP,1993) recommendation:

$$1mRh^{-1} = 0.96 \times 24 \times 365/100\ mSvh^{-1} \qquad (1)$$

### 3. Results And Discussion

**Table 1. North Direction**

| Distance (m) | GEOGRAPHICAL LOCATION | RADALERT 100 (mR/hr) | DIGILERT 50 (mR/hr) | AVERAGE (mR/hr) | EQUIVALENT DOSE RATE (mSv/yr) |
|---|---|---|---|---|---|
| 10 | N04$^0$55'11.6'' E006$^0$55'07.7'' | 0.0137 | 0.0107 | 0.0122±0.0035 | 1.026 |
| 20 | N04$^0$55'11.4'' E006$^0$55'07.6'' | 0.0170 | 0.0127 | 0.0148±0.0029 | 1.245 |
| 30 | N04$^0$55'11.1'' E006$^0$55'07.5'' | 0.0117 | 0.0107 | 0.0112±0.0024 | 0.942 |
| 40 | N04$^0$55'10.8'' E006$^0$55'07.4'' | 0.0117 | 0.0123 | 0.0113±0.0032 | 0.950 |
| 50 | N04$^0$55'10.5'' E006$^0$55'07.3'' | 0.0110 | 0.0153 | 0.0132±0.0031 | 1.110 |
| 60 | N04$^0$55'10.2'' E006$^0$55'07.3'' | 0.0093 | 0.0100 | 0.0095±0.0008 | 0.799 |
| 70 | N04$^0$55'09.9'' E006$^0$55'07.1'' | 0.0133 | 0.0123 | 0.0128±0.0040 | 1.076 |
| 80 | N04$^0$55'09.8'' E006$^0$55'06.9'' | 0.0127 | 0.0130 | 0.0128±0.0012 | 1.076 |
| 90 | N04$^0$55'09.5'' E006$^0$55'06.8'' | 0.0137 | 0.0107 | 0.0122±0.0022 | 1.026 |
| 100 | N04$^0$55'09.1'' E006$^0$55'06.7'' | 0.0120 | 0.0137 | 0.0128±0.0026 | 1.076 |
| | | **OVERALL AVERAGE** | | **0.0123±0.0026** | **1.034** |

**Table 2. South Direction**

| Distance (m) | GEOGRAPHICAL LOCATION | RADALERT 100 (mR/hr) | DIGILERT 50 (mR/hr) | AVERAGE (mR/hr) | EQUIVALENT DOSE RATE (mSv/yr) |
|---|---|---|---|---|---|
| 10 | N04$^0$55'15.2'' E006$^0$55'08.1'' | 0.0187 | 0.0137 | 0.0162±0.0035 | 1.362 |
| 20 | N04$^0$55'15.4'' E006$^0$55'08.1'' | 0.0160 | 0.0187 | 0.0174±0.0019 | 1.177 |
| 30 | N04$^0$55'15.8'' E006$^0$55'08.1'' | 0.0193 | 0.0167 | 0.0180±0.0184 | 1.514 |
| 40 | N04$^0$55'16.1'' E006$^0$55'08.2'' | 0.0163 | 0.0147 | 0.0155±0.0011 | 1.303 |
| 50 | N04$^0$55'16.4'' E006$^0$55'08.3'' | 0.0127 | 0.0130 | 0.0129±0.0002 | 1.085 |
| 60 | N04$^0$55'16.7'' E006$^0$55'08.3'' | 0.0117 | 0.0113 | 0.0115±0.0003 | 0.967 |
| 70 | N04$^0$55'16.9'' E006$^0$55'08.4'' | 0.0150 | 0.0157 | 0.0154±0.0005 | 1.295 |
| 80 | N04$^0$55'17.2'' E006$^0$55'08.6'' | 0.0147 | 0.0170 | 0.0159±0.0016 | 1.337 |
| 90 | N04$^0$55'17.4'' E006$^0$55'08.7'' | 0.0140 | 0.0137 | 0.0139±0.0002 | 1.169 |
| 100 | N04$^0$55'17.7'' E006$^0$55'08.9'' | 0.0133 | 0.0150 | 0.0142±0.0012 | 1.194 |
| | | **OVERALL AVERAGE** | | **0.0151±0.0012** | **1.270** |

**Table 3. East Direction**

| Distance (m) | GEOGRAPHICAL LOCATION | RADALERT 100 (mR/hr) | DIGILERT 50 (mR/hr) | AVERAGE (mR/hr) | EQUIVALENT DOSE RATE (mSv/yr) |
|---|---|---|---|---|---|
| 10 | N04$^0$55'14.2'' E006$^0$55'05.8'' | 0.0127 | 0.0110 | 0.0119±0.0012 | 1.001 |
| 20 | N04$^0$55'14.4'' E006$^0$55'05.6'' | 0.0107 | 0.0100 | 0.0104±0.0005 | 0.876 |
| 30 | N04$^0$55'14.4'' E006$^0$55'05.3'' | 0.0117 | 0.0113 | 0.0115±0.0003 | 0.967 |
| 40 | N04$^0$55'14.7'' E006$^0$55'05.2'' | 0.0120 | 0.0140 | 0.0130±0.0014 | 1.093 |
| 50 | N04$^0$55'14.9'' E006$^0$55'04.9'' | 0.0157 | 0.0107 | 0.0132±0.0035 | 1.110 |
| 60 | N04$^0$55'15.2'' E006$^0$55'04.6'' | 0.0137 | 0.0130 | 0.0134±0.0005 | 1.127 |
| 70 | N04$^0$55'15.4'' E006$^0$55'04.4'' | 0.0120 | 0.0097 | 0.0109±0.0016 | 0.917 |
| 80 | N04$^0$55'15.6'' E006$^0$55'04.2'' | 0.0100 | 0.0147 | 0.0124±0.0033 | 1.042 |
| 90 | N04$^0$55'15.8'' E006$^0$55'04.0'' | 0.0110 | 0.0100 | 0.0109±0.0016 | 0.917 |
| 100 | N04$^0$55'16.1'' E006$^0$55'03.8'' | 0.0100 | 0.0133 | 0.0117±0.0023 | 0.984 |
| | | **OVERALL AVERAGE** | | **0.0119±0.0015** | **1.001** |

 

**Table 4. West Direction**

| Distance (m) | GEOGRAPHICAL LOCATION | RADALERT 100 (mR/hr) | DIGILERT 50 (mR/hr) | AVERAGE (mR/hr) | EQUIVALENT DOSE RATE (mSv/yr) |
|---|---|---|---|---|---|
| 10 | N04$^0$55'13.0'' E006$^0$55'07.6'' | 0.0163 | 0.0137 | 0.0150$\pm$0.0018 | 1.261 |
| 20 | N04$^0$55'12.9'' E006$^0$55'08.0'' | 0.0147 | 0.0140 | 0.0144$\pm$0.0005 | 1.211 |
| 30 | N04$^0$55'12.9'' E006$^0$55'08.4'' | 0.0140 | 0.0137 | 0.0139$\pm$0.0002 | 1.169 |
| 40 | N04$^0$55'12.9'' E006$^0$55'08.8'' | 0.0114 | 0.0128 | 0.0121$\pm$0.0010 | 1.018 |
| 50 | N04$^0$55'12.9'' E006$^0$55'08.9'' | 0.0097 | 0.0143 | 0.0120$\pm$0.0033 | 1.009 |
| 60 | N04$^0$55'12.8'' E006$^0$55'09.2'' | 0.0117 | 0.0133 | 0.0125$\pm$0.0011 | 1.051 |
| 70 | N04$^0$55'12.7'' E006$^0$55'09.4'' | 0.0143 | 0.0127 | 0.0135$\pm$0.0011 | 1.135 |
| 80 | N04$^0$55'12.6'' E006$^0$55'09.7'' | 0.0153 | 0.0110 | 0.0132$\pm$0.0030 | 1.110 |
| 90 | N04$^0$55'12.5'' E006$^0$55'10.1'' | 0.0117 | 0.0120 | 0.0119$\pm$0.0002 | 1.001 |
| 100 | N04$^0$55'12.4'' E006$^0$55'10.3'' | 0.0133 | 0.0143 | 0.0138$\pm$0.0007 | 1.161 |
| | | **OVERALL AVERAGE** | | **0.0132$\pm$0.0013** | **1.110** |

Tables 1-4 show the terrestrial background radiation rate and total annual equivalent dose rate in the different directions from the Aluu landfill. The overall average terrestrial radioactivity values in all the cardinal directions obtained ranged from 0.0119$\pm$0.0015 to 0.0151$\pm$0.0012 mR/hr and the average equivalent doses in all the four directions calculated ranges from 1.001 to 1.270 mSv/yr. In the North Direction, a minimum value of 0.799 mSv/yr is obtained at 60 meters away from the landfill while a maximum value of 1.245mSv/yr is obtained at 20 meters away from the landfill in the North direction with an average value of 1.034mSv/yr. In the South Direction, a minimum value of 0.967mSv/yr is obtained at 60 meters away from the landfill while a maximum value of 1.514mSv/yr is obtained 30 meters away with an average value of 1.270 mSv/yr. In the East Direction, a minimum value of 0.876mSv/yr is obtained at 20 meters away from the landfill while a maximum value of 1.127mSv/yr is obtained at the 60 meters away with an average value of 1.001mSv/yr. In the West Direction, a minimum value of 1.009mSv/yr was obtained 50 meters away from the landfill while a maximum value of 1.261mSv/yr is obtained at 10 meters away with an average value of 1.110mSv/yr.

The result of the computed equivalent dose rate in the fourdirections of the landfill are slightly above the dose limit of 1.0mSv/yr for the general public and far below the dose limit of 20.0 mSv/yr for radiological workers as recommended by international Commission on Radiological Protection (ICRP, 1990). Also the result show that although 42.5% of the sampled area exceeded the accepted ICRP background level of 0.013mR/hr, the values are within the range of values previously reported in the Niger Delta region by Agbalagba and Avwiri (2008), Chad-Umoren and Briggs-Kamara(2010) and Ononugbo et al.,(2011). The overall average value in the South direction is less than the range of average background exposure rate of 0.017 mR/hr recorded in Denver, USA, which is an area of relatively high background radiation (USCF, 2002). The maximum exposure rate of 0.0180mR/hr recorded in the South Direction is mainly due to some medical sources and other hazardous materials co-disposed in the landfill. The high equivalent dose rate recorded at the major locations of the four directions of the landfill are below international permissible limit for radiological workers but marginally above the limit for the general public. The implication is that the environment is gradually becoming unsafe for the general populace in the study area.

At the present level, there is the danger of radionuclide build up in the atmosphere and precipitation may constitute radioactive pollution of rain water. Also, environmental pollution can arise from seepage from the landfill thereby making contact with the underground water and sea water. The associated radionuclide interacts with sulphates in the river and sea water where they partially precipitate and are consumed by aquatic animals, hence posing radiological risk to final human consumer ( Ononugbo et al., 2011).

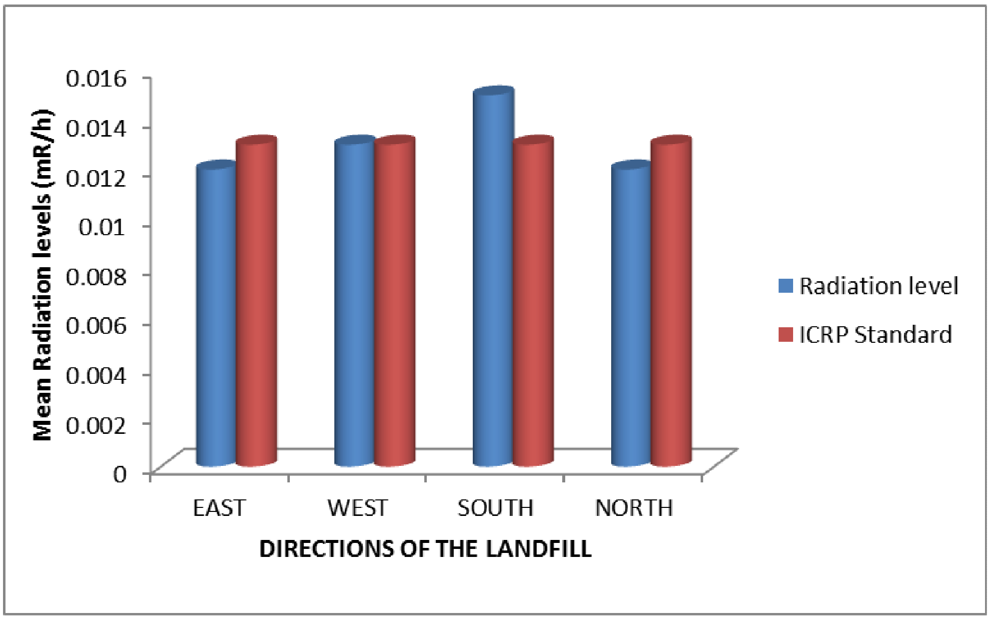


**Figure 1.** Comparison of Measured Radiation level with Normal Background of Standard

Figure 1 shows the comparison of measured radiation levels of the landfill with the normal background radiation of 0.013mR/h. The radiation level at the South Direction and west direction of Aluu landfill exceeded the normal background level while that of the East and North Direction are below the normal background level by the International Commission for Radiological Protection (ICRP, 1990) as the maximum exposure limit for members of the public. This result indicates that the refuse dump in the south and west part of the landfill are richer in radionuclide content than that of the eastern and northern of the landfill.

## 4. Conclusion

The environmental radioactivity profile of the Aluu landfill in Obiakpor local Government Area of Rivers State shows that the background radiation levels of the area have been slightly impacted by the content of the landfill. This impact is mainly due to input materials of the landfill which might be rich in Radium content. The activities of the landfill might be releasing radon gas which enhances the background radiation levels of the area. The radiation levels within the vicinities of the landfill are slightly above the normal background level of 0.013mR/h while the calculated equivalent dose obtained in the directions of the landfill exceed the safe limit of 1.0mSv/y recommended by UNSCEAR,2003 for the general public. Although our results indicate no immediate health hazards, there may be long term future health effects on the general public around the landfill area.
Considering this long term hazardous health impact, waste material must be adequately sorted out before disposing into the landfill. We also recommend that proper management and regular inspection of the landfill be taken by the government to reduce radon release to the atmosphere.

## 5. Acknowledgement

We express our sincere thanks and gratitude to the Director of the Centre for Nuclear Energy Studies (CNES) and other staff of CNES, for their sincere cooperation and help during this work. The authors are also thankful to the Management of the Nigeria Atomic Energy Commission (NAEC) for providing all logistic support to carry out this work.

## 6. References

Akinloye, M.K. & Olomo, J.B. (2005), "The radioactivity in some grasses in the environment of nuclear research facilities located within the OAU, Ile-Ife, Nigeria". *Nig. Jour. of Phy.* 17: 219- 225

Arogunjo A.M., Efuga, E.E & Afolabi, M.A. (2004). "Levels of natural radionuclide's in some Nigerian cereals and Tubes". *Jour. of Environ. Radioactivity* 82: 1-6.

Avwiri, G.O., Nte, F.U., & Olanrewaju, A.I. (2011), "Determination of Radionuclides Concentration of Landfill at Eliozu, Port Harcourt, Rivers State, Nigeria". *Scientia Africana, Vol. 10 (No.1):. pp 46-57*

Avwiri, G. O., Agbalagba, E. O., & Enyinna, P. I. (2007), "Terrestrial Radiation Around Oil and Gas Facilities in Ughelli Nigeria. Asian Network for Science Information". *Journal. Applied Sci.*, *7*(11), 1543-1546.

Farai I.P., Okwunakwe C.E. & Makinde O.S. (2007), "Gamma Spectroscopy assay soil samples from waste landfills in Port Harcourt, Nigeria". Proceedings of 16th International Conference on Radionuclide Meteorology in Cape Town. June-July, Elsevier B.V. 850-854.

Ebeniro, J.O., & Avwiri, G.O. (1998), "External Environment Radiation in an Industrial Area of Rivers, Nigeria". *Nigeria Journal Of Phsics.,* Vol. 10. 1998, 105-107.

Iloeje N.P. (1972), "A new Geography of West Africa Longman Group Ltd. Nigeria" 22-26.

ICRP (1990). "Recommendations for Radiological Protection. *International Commission for Radiological Protection". Annals of ICRP 46, p.194.*

Jibiri, N.N., Farai, I.P. & Alausa, S.K. (2007), "Activity concentration of Ra-226, Ra- 228 and K-40 in food crops from high background radiation area in Bisichi, Jos, Plateau State, Nigeria". Radiat. Env. Biophy. 46: 53 – 59.

Laogun, A. A., Ajayi, N. O. & Agaja, S. A. (2006), "Variation in Wellhead Gamma Radiation Levels at the Nigeria Petroleum Development Company Oil Field, Ologbo Ede State, Nigeria". *Nigeria. Journal of Physics.* 18(1), 135-140.

Louis E.A., Etuk, E.S & Essien U. (2005), "Environmental Radioactivity Levels in Ikot Ekpene, Nigeria". Nigeria Journal of Space Research 1: 80-87.

Odunaike R.K., Laoye J.A., Alausa S.K., Ijeoma, G. C., & Adelaja, A.D. (2008), "Radiation Emission Characterization
of Waste Dumpsites in the City of Ibadan in Oyo State of Nigeria", Research Journal of Environmental Toxicology (2) Vol, 2: 100 – 103.

Ononugbo, C.P., Avwiri,G.O. & Chad-Umoren Y.E. (2011), "Impact of Gas Exploitation on the Environmental Radioactivity of Ogba/Egbema/Ndoni Area, Nigeria". Energy and Environment 22(8), 1018-1027.

Shapiro, J., (1981),"Radiation Protection, A Guide for Scientists and Physicians", Second Edition, Havard University Press, USA.

Udom, G.J.& Esu, E.O. (2004), ""'A preliminary Assessment of the Impact of Solid wastes on soil and groundwater system in parts of Port-Harcourt City and its Environs, Nigeria. Vol. 4(1) 23-32.

USCF (2002), "Radiation Safety Training Manual", Office of Environmental Health and Safety, University of California, San Francisco USCF.