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Evaluation of Radiation Emmission from Refuse Dump Sites in Owerri, Nigeria

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Abstract: *The natural radioactivity concentrations from 40 different locations of waste dump sites in Owerri, Imo state Nigeria, has been measured using a gamma – ray spectrometer. The results indicate that the ranges of activity concentrations of ^{40}K, ^{226}Ra and ^{323}Th in the samples were <17.2 – 686.17 $BqKg^{-1}$, < 4.2 – 103.51 $BqKg^{-1}$ and < 5.1 – 65.28 $BqKg^{-1}$ respectively. The highest outdoor effective dose obtained was 65.28 $\mu Sv.y^{-1}$ which is less than the world average outdoor value of 70 $\mu Sv.y^{-1}$ given by United Nations Scientific Committee on the Effect of Atomic Radiation (UNSCEAR)*

Keywords: *Activity Concentration, Radiation Emission, Waste Dumpsites, Absorbed Dose rate, Effective Dose Equivalent*

I. Introduction

Refuse dump site constitute an environmental health hazards to the public in major cities of the world not only in terms of the odors or the presence of disease causing micro – organisms, but the radiation emanating from such dump sites (Ojoawo et al 2011, P .661- 666). In the past few decades, nuclear applications have been on the increase worldwide and so is the risks of abuse and accident. It is therefore important to measure the levels of the different components of radiation present in the environment at a given time in order to adequately assess the risk to the population. The sources of most of the naturally occurring radioactive isotopes are those of ^{238}U and ^{232}Th and their progeny. Other radionuclide of concern are those formed from the decay of ^{226}Ra and ^{228}Ra. Radium (Ra) which is slightly soluble in water can be mobilized in the liquid phase of a subsurface formation and transported to the surface. There are also man – made sources such as ^{137}Cs, ^{434}Cs, ^{90}Sr etc which are usually released and dispersed from nuclear power plants. These man – made sources add to the radiation levels due to the natural background radiation whenever they are released into the environment. Naturally Occurring Radioactive Materials (NORM) give rise to a very much larger radiological effect on the public than that caused by the nuclear industry and other anthropogenic sources of radiation because of their wide distribution (UNSCEAR 2000).

Owerri is the capital of Imo State Nigeria, from the time it was created in 1967 till date. It has grown from a small town to become one of the commercial hubs of the South – Eastern Nigeria. Owerri is also a gate way city from the South-Western to most of the South – Eastern part of Nigeria. For example crossing from the South – Western part of Nigeria to cities like Aba, Calabar, Uyo, Port Harcourt, Okigwe etc must pass through Owerri. As a result, there has been great increase in commercial activities and human settlement in the resent years. These commercial activities has seen people from all works of life bringing in wares from within and outside the country to sell in Owerri. The waste products of these materials are usually indiscriminately dump in open fields (Ojoawo et al 2011 P.661 – 666), farm soils (Jibiri et al 20011 P.1039 – 1049), rivers (Farai and Oni 2002 P.94 – 97) and even on road sides and mechanic workshops (Nworgu et al 2011P. 801 – 805) . In these way, there is every likely hood of dumping radioactive materials knowingly or unknowingly into the refuse dump which could pose a very great health hazard to the public. This is of very great concern because over the years, waste disposal operations has not been regulated in Nigeria. This will provide a base line data for the National Council on Radiation Protection and Management (NCRM) to determine the average annual outdoor radiation exposed to the members of the public in Owerri. Prolong exposure of the public to radioactivity is very dangerous if it is not detected and checked. The United Nations Scientific Committee on the Effects of Atomic Radiations (UNSCEAR) recommends a maximum standard average value of 2mSv per annum of exposure to the members of the public above which there will be a great risk of cancer (UNSCEAR 2000).

In view of worldwide concern for the radioactivity concentration emanating from refuse dump sites of major commercial cities in Nigeria and beyond, data is scares for the activity concentration of dumps sites in Owerri. This implies that it is impossible to accurately assess the occupational and public health burden due to these natural radioactive materials in the refuse dumps. Though efforts has been in progress in environmental radioactivity studies of major cities in Nigeria from which some results have been reported (Farai and Jibiri

2000, P.247 – 254, Obed et al 2005 P. 305 – 312), no measurements has been made to ascertain the health risk due to the radioactive concentrations of refuse dumps in Owerri. The result of the study may be a basis to equally advise the government on waste disposal management in Owerri in order to safe guide the lives of the public from radioactive effects. The purpose of this research was therefore to

1. Determine the radioactive concentration of the of the refuse dump sites in Owerri Imo State.
2. to monitor possible environmental radioactive contamination from artificial sources.
3. to obtain radiometric data for future references and research in the area.

II. Materials and Methods

Owerri has a major refuse – dump site along Owerri Aba road opposite dipper park, and minor dump sites at different locations all around the city. 20 samples were collected from the major dump sites while 20 samples were collected from the minor dump sites to make it a total of 40 samples. The map of the study area showing the locations where samples were collected is shown in Figure 1.These were collected into a labeled water proof nylon bag and transported to the radiation laboratory for analysis. The samples were air – dried and homogenized to pass a 1mm mesh sieve. About 0.2Kg of the sample were weighed and transferred into a plastic of about 8cm in height and 7cm in diameter which has been verified to be non radioactive. The samples were sealed for about 28 days for the short lived members of Radon – 222 and Radon – 220 series to reach a secular equilibrium. The samples were placed symmetrically each on top of the detector and measured for 10hours (36000s). The net area under the corresponding photopeaks in the energy spectrum was computed by subtracting count due to Compton scattering of the background source from the total area of the photopeaks. The radionuclides were computed using the algorithm of the multichannel analyzer (MCA). The map of the dump sites in which refuse were collected are attached here with as figure1.

The scintillation detector used in this work is a lead shield Canberra 76mm x 76mm NaI(Ti) crystal models number 802 – series. One face of the cylindrical detector is free while the other is optically coupled to a Photomultiplier tube which detects the small visible light photons produced in the crystal and converts them into amplified electrical pulses which is fed into analyzer systems (Canberra series 10 plus multichannel analyzer MCA) through a preamplifier base.

The gamma spectrometry detector was calibrated before it was used for analysis. This was done to ensure that the radiation parameters in the samples could be expressed in physical radiometric units. This calibration was done in two stages. This is energy calibration and efficiency calibration. The energy calibration convert channel numbers to γ - ray energy in Mev. This was done by placing different gamma sources of known energy on the detector at a distance of 7cm from it. After a preset counting time of 100s, the channels of the various photopeaks corresponding to the gamma energies were identified. The channel numbers corresponding to the gamma energies are given in Table[1]. The efficiency calibration was to determine the gamma ray counting efficiencies over energy range of 0.662 – 2.615 MeV. This was done by converting the count per seconds under the photopeaks to activity concentration Bq/kg of certified reference standard samples. The certified reference standard samples have activity concentrations of 7.24 Bq/kg for ^{137}Cs (0.662 MeV), 510.00 Bq/kg for ^{40}K (1.460 MeV), 631.00 Bq/kg for ^{226}Ra (1.760 MeV) and 11.00 Bq/kg for ^{232}Th (2.615 MeV). Efficiencies at different gamma energy peaks are given in Table[2]. The reference standard sources were counted for 10 hours (36,000s) after which the counting efficiencies of the different gamma energies were determined. According to Obed et al and 2005 and Jibiri et al 2007, the count rate A_{net} under the photopeak of each of the three primordial radionuclides is related to activity concentration by the equation 1.

$$\varepsilon_\gamma = \frac{A_{net}}{A_s Y_\gamma M_s t} \qquad 1$$

Where ε_γ = the efficiency of the detector at a particular γ – energy

A_{net} = count rate under the photopeak of the 3 primordial radionuclides,
Y_γ = the yield of the gamma ray at a particular energy,
M_s = the mass of the samples (0.2Kg)
t_s = the counting time in seconds.

The efficiencies (ε_γ) for each of the 4 gamma energies are given in Table[2].

The lower limits of the detection (LLD) of the detector for the concentrations of the radionuclides in the samples were also determined. The values were 17.2 Bq/Kg for ^{40}K, 4.2 Bq/Kg for ^{226}Ra and 5.1 Bq/Kg for ^{228}Th. Values below these numbers were taken in this work as being below the detection limit (BDL) of the detector. The result of the activity concentration of the 40 samples collected from different locations are presented in Table[3].

Nuclides	Energy (MeV)	Channel number
Na-22	0.511	110
Cs-137	0.662	146
Co-60	1.173	256
K-40	1.460	312
Ra-226	1.760	376
Th-232	2.615	552

Table[1]. Energy table with the corresponding channel numbers.

Radionuclide	Energy (MeV)	Gamma Yield	Area Count/25200s)	Efficiency (%)
Cs-137	0.662	0.852	2476	5.57
K- 40	1.460	0.107	8342	1.87
Ra-226	1.760	0.159	400	1.67
Th-232	2.615	0.358	364	1.35

Table[2]. Efficiencies at different gamma energy peaks.

III. Results and Discussion

	^{40}K (BqKg^{-1})	^{226}Ra (BqKg^{-1})	^{232}Th (BqKg^{-1})
1	488.18 ± 8.68	25..19 ± 7.94	18.21 ± 58.17
2	559.28 ± 10.42	BDL	8.82 ± 11.44
3	562.21 ± 8.35	22.63 ± 8.72	BDL
4	32.99 ± 14.33	103.51 ± 67.02	BDL
5	460.32 ± 4.06	BDL	BDL
6	371.63 ± 10.06	BDL	BDL
7	291.73 ± 11.53	17.27 ± 45.17	BDL
8	502.11 ± 4.39	14.48 ± 30.38	BDL
9	240.42 ± 11.49	15.58 ± 47.23	19.23 ± 11.27
10	BDL	BDL	5.37 ± 3.52
11	BDL	BDL	BDL
12	319.59 ± 10.51	7.87 ± 25.80	20.59 ± 2.92
13	227.23 ± 9.69	13.72 ± 32.87	26.74 ± 7.23
14	157.60 ± 4.85	11.68 ± 4.15	21.61 ± 2.59
15	311.53 ± 11.52	7.85 ± 1.40	55.16 ± 9.63
16	328.38 ± 8.96	BDL	50.43 ± 5.97
17	227.96 ± 8.99	7.24 ± 4.31	22.50 ± 6.19
18	277.81 ± 9.77	6.73 ± 1.41	42.72 ± 7.97
19	253.62 ± 9.19	BDL	35.50 ± 6.59
20	468.39 ± 95.09	6.60 ± 1.44	19.46 ± 6.97
21	527.76 ± 13.02	7.87 ± 1.87	BDL
22	399.49 ± 11.69	17.78 ± 5.88	13.22 ± 3.16
23	505.77 ± 15.42	6.48 ± 1.90	16.32 ± 7.92
24	398.02 ± 12.57	5.33 ± 1.19	22.36 ± 9.98
25	414.88 ± 15.38	12.83 ± 3.08	14.24 ± 4.87
26	502.11 ± 41.16	22.48 ± 3.78	15.25 ± 2.07
27	461.06 ± 12.34	26.16 ± 7.98	10.30 ± 9.87
28	448.60 ± 13.14	BDL	12.01 ± 4.12
29	460.32 ± 13.66	33.15 ± 8.95	12.64 ± 7.03
30	281.32 ± 12.90	21.16 ± 5.43	6.43 ± 1.01
31	344.12 ± 8.76	18.33 ± 4.94	10.28 ± 3.44
32	448.71 ± 18.53	12.67 ± 6.32	9.29 ± 4.31
33	388.17 ± 14.35	14.19 ± 1.76	11.09 ± 2.19
34	449.17 ± 18.44	22.27 ± 7.32	16.27 ± 6.65
35	531.35 ± 19.09	19.77 ± 8.07	21.34 ± 3.02
36	686.17 ± 42.11	BDL	7.33 ± 3.21
37	108.31 ± 17.27	BDL	BDL
38	586.62 ± 30.21	13.12 ± 2.87	BDL
39	410.31 ± 56.43	21.14 ± 7.97	12.31 ± 3.85
40	214.71 ± 62.98	BDL	6.31 ± 0.99

Table[3]. The soil activity concentrations at different locations and their error terms.

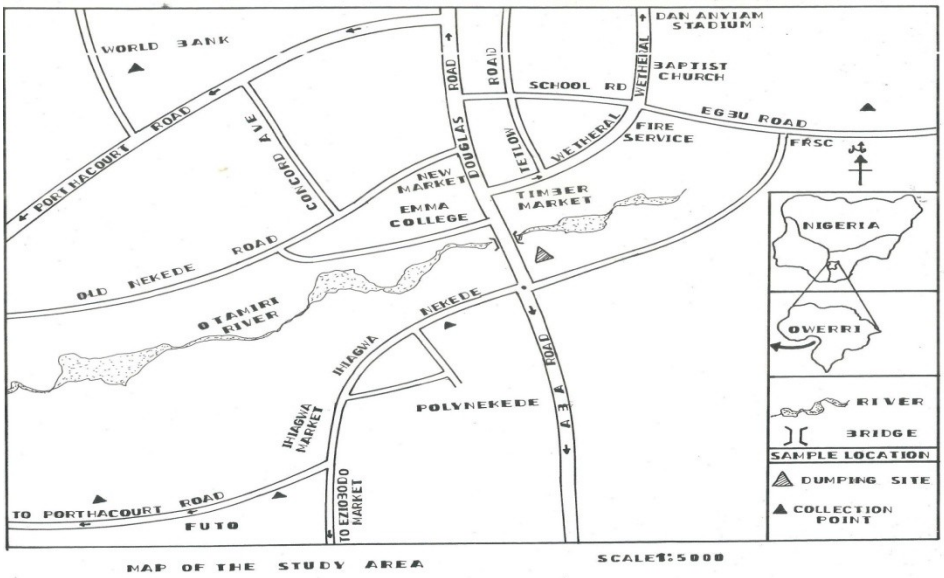

Figure 1. A map of the study area showing the locations where samples were collected

The absorbed dose rate, D ($nGyh^{-1}$) in air at 1m above the ground level for soils containing the concentrations of the radionuclides measured in the samples was calculated using the equation

$$D = aC_k + bC_{Th} + cC_{Ra} + dC_{Cs} \qquad (2)$$

Where a is the dose rate per unit ^{40}K activity concentration ($0.042\ Gyh^{-1}$), C_k is the concentration of ^{40}K in the sample in ($BqKg^{-1}$), b is the dose rate per unit ^{232}Th activity concentration ($0.666Gyh^{-1}$), C_{Th} is the concentration of ^{232}Th in the sample in ($BqKg^{-1}$), c is the dose rate per unit ^{226}Ra activity concentration (0.429 Gyh^{-1}), C_{Ra} is the concentration of ^{226}Ra in the sample in($BqKg^{-1}$), d is the dose rate per unit ^{137}Cs activity concentration ($0.30Gyh^{-1}$) and Cs is the concentration of ^{137}Cs in the sample ($BqKg^{-1}$). Since Cesium – 137 was not detected in any of the samples, the last term in equation (2) was taken as zero. The absorbed gamma dose rates in air are usually related to human absorbed gamma dose in order to assess radiological implications.

As a further step to evaluating the population dose due to outdoor gamma radiation , the annual collective effective dose equivalent to members of the population was assessed according to ICPR. In doing this, two factors were considered. The first was a factor that converts the absorbed dose rate (Gyh^{-1}) in air to human outdoor effective dose rate (Svy^{-1}), while the second factor is the proportion of total time for which a typical individual was exposed to outdoor or indoor radiation. The United Nations Scientific Committee on the Effect of Atomic Radiation (UNSCEA 2000) recommended $0.7SvGy^{-1}$ as the value of the first factor while 0.2 and 0.8 as for outdoor and indoor occupancy factor respectively. A 0.2 outdoor occupancy factor means that an average spends about 17280s outdoors. In this work, only outdoor exposures from gamma ray sources were considered. The effective dose rate values was calculated using the equation:

$$E_{air} = TfQD_{air}\varepsilon \qquad (3)$$

where E_{air} is the effective dose rate (μSvy^{-1}), T is the time ($8766hy^{-1}$), f is the outdoor occupancy factor that corrects for the average time spent outdoor (0.2), Q is the quotient of the absorbed dose rate in air ($0.7\ SvGy^{-1}$), D_{air} is the absorbed dose rate in air and ε is the factor converting nano (10^{-9}) to micro (10^{-6}). The result of the absorbed dose rate in $nGyh^{-1}$) and effective dose equivalent in ($\mu Sv.y^{-1}$**)** is presented in Table[4]

S/N	Dose rate ± σ($nGyh^{-1}$)	Effective dose equivalent ($\mu Sv.y^{-1}$)
1	43.44 ± 14.3	53.31
2	28.60 ± 8.60	35.10
3	21.54 ± 24.07	26.44
4	36.17 ± 8.60	44.39
5	17.12 ± 4.30	21.01
6	12.66 ± 3.09	15.54
7	22.68 ± 9.73	27.83
8	28.42 ± 7.30	34.88
9	29.59 ± 4.90	36.31
10	0.00	0.00
11	0.00	0.00
12	30.51 ± 8.20	37.44
13	33.24 ± 5.90	40.79

14	26.02 ± 6.90	31.93
15	53.19 ± 9.10	65.28
16	41.39 ± 9.77	50.80
17	27.67 ± 5.70	33.96
18	40.09 ± 9.70	50.19
19	28.46 ± 7.03	34.93
20	35.47 ± 9.50	43.53
21	25.54 ± 7.50	31.34
22	33.21 ± 7.46	40.76
23	34.89 ± 9.44	42.82
24	33.80 ± 8.09	41.48
25	32.41 ± 8.42	39.77
26	40.89 ± 14.33	50.18
27	37.44 ± 8.07	45.95
28	26.84 ± 7.84	32.94
29	41.98 ± 9.80	51.52
30	25.18 ± 8.03	30.90
31	29.16 ± 6.63	35.79
32	30.47 ± 9.40	37.39
33	29.78 ± 8.62	36.55
34	39.26 ± 9.20	48.18
35	45.01 ± 9.45	55.24
36	33.70 ± 7.42	41.36
37	4.44 ± 0.25	5.46
38	30.27 ± 7.34	37.15
39	34.50 ± 7.91	42.34
40	13.22 ± 4.06	16.22

Table [4]. The absorbed dose rate and the effective dose equivalent

IV. Conclusion

The three primordial radionuclides have been detected and measured in 40 different locations of refuse dump sites in Owerri metropolis in Imo state Nigeria. Despite the fact that all levels of ionizing radiation are hazardous to human health (Imtiaz et al. 2005, P. 169-174) the exposure level of the emitted radiation on the populace in Owerri is low compared with Nigeria and World average which is $70\mu Svy^{-1}$. Hence, fear of serious health hazard arising from the exposure to radiation emanating from these refuse dump sites should not be entertained. However, focus should be on the proper management of the waste generated in Owerri to prevent outbreak of mutual, cancerous diseases and also to prevent harmful micro organisms and the radiation emitted from the dump sites from getting into exposed food sold in this areas. It will be wise to improve the environment and conserve natural resources. These can be achieved by locating waste dump sites far away from residential areas and also discourage people from building houses near dump sites (Olubosede et al. 2012 P. 806- 811). For all practical purposes, the values obtained in this study for Owerri could be taken to represent the baseline of natural radioactivity. This could be used as a yard stick for evaluating the extent of any pollution in the environment due to any accidental release of radionuclides.

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