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Measurement of Gamma Radiation from Some Selected Refuse Dumpsites in Yola Metropolis, North-Eastern Nigeria

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Abstract: *Many forms of radiation known as "ionizing radiations" are encountered in the natural environment some of which are produced by modern technology. Most of them have the potential for both beneficial and harmful effects. These radiations can disrupt atoms, creating positive ions and negative electrons, and cause harm. Ionizing radiations include x-rays, gamma rays, alpha particle, beta particles, neutrons and the varieties of cosmic rays. This paper is based on the measurement of gamma radiation from selected refuse dumpsites in Yola metropolis, North-Eastern Nigeria. Background ionization radiation measurements were carried out in five refuse dumpsites. An in situ measurement was done using a well calibrated nuclear radiation meter, RADALART MONITOR-4. Readings were taken once in a week for a month. The mean background ionizing radiation values in all the five dumpsites is 0.015 mR/hr with a standard deviation of 0.0024. This value was higher than the normal background standard value of 0.013 mR/hr which indicate no immediate but a long-term health hazards to the dumpsite workers and residents of the host communities.*

Keywords*: Gamma Radiation, Refuse Dumpsites, Background Radiation, Waste disposal*

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I. Introduction

All ionizing radiations, at sufficiently large exposures, can cause cancer (Crosbie and Gittus, 2003). Many in careful controlled exposures are used for cancer therapy. Thus, radiation is an old and familiar pollutant. People live in a society where there is indiscriminate disposal of refuse. Not until they awake to their responsibilities and curb this menace, our society is potentially at risk of radiation hazard (Gbadebo *et al*, 2012).

Gamma radiations are radiations without charge (i.e. neither negatively nor positively charged) but characterized by a very high penetration ability. Unlike X-rays, alpha particles and beta particles which are all ionizing radiations, gamma radiations can cause more serious damage to natural cells. Some plastics, material casings (especially electronics casings), disposals from abattoirs, refuse from homes, offices, industries, mechanical and electrical workshops are the major components of municipal waste in most places. Amazingly, they are possible sources of radioactive materials which in turn may become sources of gamma radiation (Arvwiri and Olatubosun, 2014).

Exposure to sources of radiation could lead to acute radiation doses which can be a means of proliferation of cancer in a community (Yves & Alessandra, 2009). Most naturally occurring radionuclides are potential sources of gamma rays, particularly, K – 40 which is present in meat, banana, mushroom, avocados etc. and they form part of the constituents of refuse in most dumpsites in Yola (Yves & Alessandra, 2009).

Gamma radiation can cause alteration in the chemical composition of the soil, alter plant physiology, pose a threat to aquatic life and can affect human genetically (Fardous *et al*., 2013).

The discovery of gamma ray was done by the French physicist and chemist Paul Villard Ulrich and later classification and naming was done by Ernest Rutherford in 1903. This opened the door of scientific research, experiences, articles, books, and other academic materials being documented with regards to finding out the amount of gamma radiation in our environment using different methods and monitoring instruments round the world.

The first gamma ray source to be discovered historically was the radioactive decay process called gamma decay. In this type of decay, an excited nucleus emits a gamma ray almost upon formation. Paul Ulrich Villard discovered gamma radiation in 1900 while studying radiation emitted from radium. He knew that this described radiation was more powerful than previously described types of rays from Radium which included beta rays first noted as radioactivity by Henri Becquerel in 1896 and alpha rays discovered as less penetrating form of radiation by Rutherford in 1899. However, Villard did not consider naming them as fundamental types. His radiation was recognized as being distinct from previously named rays by Ernest Rutherford who later in

1903 named Villard's rays as "gamma rays" by analogy with beta and alpha particles which he (Rutherford) had differentiated in 1899 (Kirstin, 2015).

The rays emitted by radioactive elements were named in order of their penetrating power using the first three Greek alphabets (α, β and γ). Alpha (α) particles are the least penetrating, followed by beta (β) particles and gamma (γ) rays. Rutherford also noted that the later (γ-rays) were not deflected (or at least easily deflected) by a magnetic field which is another distinguishing feature of this rays from alpha and beta particles.

According to the survey in Nigeria, Akoshile and Nwankwo (2005) measured the background radiation level in Offa industrial area of Kwara State, West-central Nigeria. The measurement was carried out using two digital alert nuclear radiation monitors calibrated with Strontium – 90. The following units were obtained 0.017 mR/hr, 0.119 mR/hr, 0.013 mR/hr, 0.014 mR/hr and 0.14 mR/hr. An average of 0.123 mR/hr count rate was obtained for the background radiation level, which is well above the standard level of 0.013 mR/hr (Aku and Augustine, 2012).

Adeniyi *et al.,* (2010) measured the background radiation in two tertiary institutions in Minna, North-west Nigeria. A portable Geiger-Muller tube based environmental dosimeter was used. The dose rate obtained at the Niger State College of Education Minna (NCEM) varies from 0.125 $\mu Svhr^{-1}$ to 0.17 $\mu Svhr^{-1}$ and at the Federal University of Technology Minna, Bosso Campus (FUTB), it was between 0.152 μSv/hr to 0.171 $\mu Svhr^{-1}$ and at the Federal University of Technology Minna, Gidankwano Campus (FUTG) it was between 0.137 $\mu Svhr^{-1}$. The mean dose rate was 0.154 $\mu Svhr^{-1}$ with standard deviation of 0.017 $\mu Svhr^{-1}$.

Agba and Sadiq (2011) measured the background radiation in Akwanga, Nassarawa State of North-central Nigeria. The measurement was done using an inspector alert nuclear radiation meter 3500 cpm mR/hr, gamma sensitivity referred to as CS – 137 with an inbuilt Halogen quenched Geiger-Muller tube. The indoor readings range from 1.04 to 1.75 $mSvhr^{-1}$ while the outdoor radiations ranged from 0.24 to 0.44 $mSvhr^{-1}$. The annual mean equivalent doses for indoor and outdoor background radiations are 1.29±0.13 mSvh/yr to 0.3±0.14 mSvh/yr.

Adekoya, *et al.,* (2012) measured the radiation dose rate level around a nuclear establishment in Abuja North-Central. The radiation measurement was carried out using RDS-200 universal survey meter. It was observed that the dose equivalent rate varied from 0.106±0.032 μSv/hr to 0.212±0.0036 μSv/hr with a mean of 0.149 ± 0.032 μSv/hr.

Moses *et al.,* (2013) assessed the gamma dose rate in Idu industrial area of Federal Capital Territory (FCT) Abuja. The measurement was carried out with a radiation monitor Atomex AT1117 m with serial number 14199. It was observed that the average dose equivalent varied from 0.106 ± 0.001 μSv/hr to 0.139 ± 0.004 μSv/hr with a mean of 0.177 ± 0.006 μSv/hr.

Arvwiri and Emmanuel (2014) evaluated background radiation levels in some selected dumpsites in North Local Government Area of Uvwie, Udu and Ugheli, Delta State, Nigeria. Background ionization radiation measurements were carried out in five dumpsites. An *In-situ* measurement was done using a well calibrated nuclear radiation Radalert – 100 and a Geographic Positioning System (GPS). Reading were taken once in a week for one month in ten different locations within each of the dumpsites. The mean background ionization radiation values in all the five dumpsites ranges from 0.017 ± 0.006 mR/hr to 0.18 ± 0.007 mR/hr. All the background ionization levels obtained values exceeded the normal world average background ionization Radiation (BIR) level of 0.013 mR/hr. The mean absorbed dose rate values ranges from 1.430 mSv/yr to 1.541 mSv/yr. The result showed that all the dumpsites yearly absorbed dose rate exceeded the 1.0 mSv/yr maximum permissible limit recommended for the public and non-nuclear industrial environment by international council on Radiological protection (Radiation induced Centre, 2015; Adekoya, *et al.*, 2012). Their work indicated that this dumpsite areas of Delta State had background radiation exceeding the permissible limit.

This paper presents measurement of the average amount of gamma radiation emitted from some selected refuse dump site in Yola metropolitan and compares it with the world allowable level stated by the United Nation's Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) specifications.

II. Methodology

Yola Metropolis comprises of Yola North, Some parts of Yola South and Girei Local Government Areas, in Adamawa State Nigeria. The City with an elevation of 599 meters, with coordinates: $9^0 17'0''$ north, $12^0 28'0''$ east, according to 2006 National Census, had an average population of 392,854 residents with a population density of 470 per km^2. This fast growing city is predominantly made up civil servants, business men, and some farmers. It experiences Hamattan, dry and wet seasons with variations in the micro climate of the area. The temperature in the city is always higher in February and April (Adebayo & Zemba, 2003).

Five (5) dumpsites in the metropolitan council (Girei-Jimeta-Yola local governments) were selected with special consideration to choosing the northern, central and southern areas of the metropolis viz:

(i) **Doubeli A,** (DA): is located very close to the river Benue Bridge in Doubeli North-Eastern Area of the metropolis

(ii) **Doubeli B,** (DB): is directly opposite Doubeli Primary school, North Central Area of the metropolis
(iii) **Doubeli C,** (DC): is located at the roundabout, close to the Jambutu by-pass, the Western Area of the Metropolis
(iv) **Jippu Jam,** (JJ): is located around the Jippu-jam round about in Yola town, Southern Area of the metropolis
(v) **Yola Market,** (YM): is located around the Yola market, after the main Yola bus terminus, South-Eastern Area of the metropolis

All these dumpsites consists of wastes that comprised of both organic and non-degradable waste e.g. metals, glass and polythene. The metals are packed from some blacksmiths and metal mechanics shops while most of the polythene were brought from a factory (BAJABURE) and the residents of these dump points.

Data Acquisition Equipment

The research was carried out using the radiation alert monitor (RADALART MONITOR-4), which senses ionizing radiation by means of a GM (Geiger-Muller) tube with a thin mica end window. The tube is fully enclosed inside the instrument. When a ray or particle of ionizing radiation strikes the tube, it is sensed electronically and displayed by a flashing count light.

Factory calibration of the instrument is by pulse generator and is typically ±10% of full scale relative to Cesium 137. This instrument detects alpha particles down to 2.5 MeV; typical detection efficiency at 3.6 MeV is greater than 80%. Detects beta particles at 50 keV with typical detection efficiency of 35%. Detects X-rays and gamma rays down to 10 keV typical (uncompensated). Detects X-rays and gamma radiations through the sidewall. Normal background is approximately 10-20 CPM. The operating voltage for this instrument is 7-11 Volts of DC. The temperature range is -20 ^{0}C to +50 ^{0}C. The battery has a life span of up to 2000 hours. The power requirement is one 9 V battery.

Data Collection

The radiation alert monitor was placed in a plastic casing that was constructed to block other background radiation from penetrating in through the mica window to the GM-tube. The instrument was mounted on a wooden stand one meter high and moved across the refuse heap. The audio knob was turned on and counts were noted per minute (CPM) and the readings were recorded as the needle indicator deflects through the scale. The radiation was observed for one month. The group data of the radiation records were presented in table 1.
The mean and the standard deviation were calculated using.

$$Mean, \bar{x} = \frac{\sum fx}{\sum f} \tag{1}$$

$$S\tan dard\ Deviation, S = \sqrt{\frac{\sum_{i=1}^{n} f\left(x_i - \bar{x}\right)^2}{\sum f}} = \sqrt{\frac{\sum_{i=1}^{n} fd^2}{\sum f}} \tag{2}$$

where *f* is the frequency of data, x collected for the period.

III. Results And Discussions

The results of the radiation records in all the identified study dumpsites were presented in Figure 1. The data was grouped, the arithmetic mean for the whole period of study was computed using equations (1) and (2). The component bar chart is the plot of the results for an easy comparison

Table 1 Grouped data of the results of radiation records

x	*f*	*fx*	*d=(x - $\bar{x}$)*	d^2 $(x10^{-6})$	$fd^2(x10^{-6})$
0.014	4	0.056	- 0.001	1.00	4.00
0.015	2	0.030	0.000	0.00	0.00
0.016	3	0.048	0.001	1.00	3.00
0.017	5	0.085	0.002	4.00	20.00
0.018	2	0.036	0.003	9.00	18.00
0.019	3	0.030	0.004	16.00	48.00
0.020	1	0.020	0.005	25.00	25.00
	$\sum f=20$	**0.305**			$\sum fd^2$**=118**

Using (1) and (2), the mean, x = 0.0153 mR/hr and the standard deviation, s = 0.0024 mR/hr (to 5 significant figures). With the standard BIR of 0.013 mR/hr this indicated that the average radiation level is little above the standard indicating that cautionary measures has to be taken to check the dumpsites regularly to tackle adverse health hazards as reported by Sodickson *et al*., (2009).

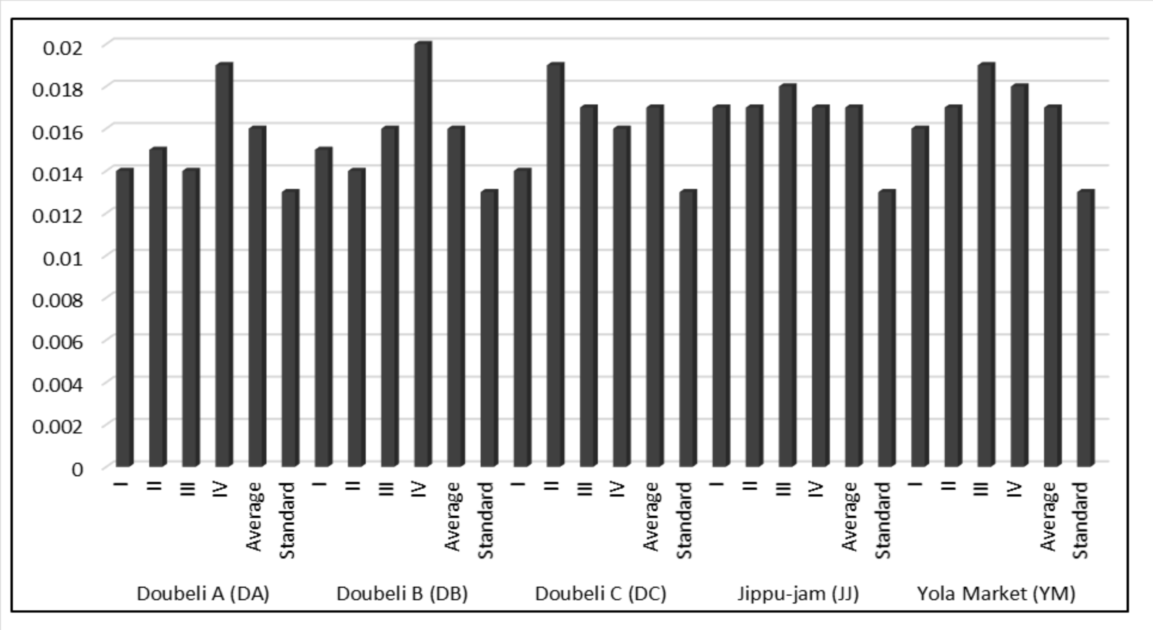

Figure 1: A Component bar chart showing the data for each weekly and the monthly average values in comparison with the Standard **BIR** level, in mRhr^{-1} (BIRS-Background Ionizing Radiation Standard)

As shown in fig.1, the data was recorded as the weekly average in the refuse dumpsites. From the chart, the least value was 0.014 mR/hr and the highest value 0.019 m/R/hr All these values are above the average background ionizing radiation standard of 0.013 mR/hr. Doubeli A had values between 0.014 to 0.15 mR/hr, In the case of Doubeli B, the least value was 0.014 mR/hr while the highest value recorded was 0.020 mR/hr. Doubeli C had values ranging from 0.014 to 0.019 mR/hr. Jippu jam has values between 0.017 and 0.018 mR/hr and finally that of Yola market was found to lie between 0.016 to 0.019 mR/hr. This high value could be attributed to the activities taking place at the Yola market most especially the blacksmiths and those selling agrochemicals whose refuse is directly the source of the lumps in the dumpsite. This was the same characteristics observed by Adeniyi *et al*., (2010) and Adekoya *et al.*, (2012) from their respective works on Minna and Lagos all in Nigeria.

IV. Conclusion

The mean radiation values obtained in each dumpsites was higher than the normal background standard of 0.013 mR/hr. The reported values may indicate no immediate health hazards, but may cause long-term health hazards to the dumpsite workers and residents of the host communities due to increase in longer periods of operations as suggested by Sodickson *et al*., (2009).

It could be necessary to suggest that there should be a shift system by the Environmental sanitation staff working in these sites due to the fact that the amount of radiation absorbed depends on the time spent in the area, distance or closeness to the source of radiation and shielding. Consequently, the following points should be considered.

(i) Waste material should be adequately checked at the collation point.
(ii) There should be a regular measurement of background ionizing radiation levels in these locations.
(iii) Dumpsite workers should operate shift system if they don’t do it before.
(iv) Refuse dumpsite workers should be provided with TLD badges, film badges or EPD badges (personal dosimeters) to monitor the radiation dose absorbed by them.

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