# Assessment of Radiation Emission Levels in Industrial Sites of Ibadan Metropolis Nigeria

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***Abstract:*** **The increase in population of major cities in Nigeria has caused proliferation of industries around them especially Ibadan. Hence, the rate and the volume of the waste generated equally increases. This can be a source of environmental health hazard and possible radiation emission from each industrial site to the workers and close residential areas calls for a concern. Hence, the aim of this study is to assess radiation emission levels in industrial sites of Ibadan metropolis. The industrial sites are mainly located in Oluyole L.G.A of Ibadan. A portable radiation survey meter RDS-30 with serial number 270354 was used to quantify the exposure levels in the industrial sites. The absorbed dose rates were determined at 10 different industries of the study area. The highest stable point was observed while radiation survey meter was placed at the level of Gonad at 1metre above the ground level. The procedure was repeated three times at the same point in the industrial site. An average mean value and standard deviation were determined for each of the locations. Radiological hazard indices were calculated from the data obtained. The mean background reading was 0.09uSvh$^{-1}$. The mean equivalent dose was 0.14 uSvh$^{-1}$, the mean absorbed doe rate (ADR) was 142nGyh$^{-1}$. The calculated annual exposure dose rate (AEDR) was 0.17mSvy$^{-1}$. The corresponding estimated ECLR was 0.60X10$^{-3}$. However, from the result of the study, it was observed that proper and continuous evaluation of dose level should be maintained to avoid any possible health effect of radiation.**

***Key Words*: Radiation, Emission, Levels, Ibadan, Exposure, Dose**

## I. INTRODUCTION

The advent of high developmental activities in the 21st century could not be over emphasized, especially in the areas of technology, medicine, agriculture, industrialization and many others (Rahman, 2011). This combined with increase in human population around the globe has made the 21st century the era of modern development, which thus increase human and financial resources around the developing nations (Krueger, 1997). The developmental process in Africa particularly in Nigeria has increased tremendously over the last decades. As regards to this study, this paradigm of change has not left out the African second largest city called Ibadan (Ogbuozobe, 1996). Ibadan is the capital of Oyo state which is located in the southwestern geo-political zone of Nigeria. This description becomes quite understandable when it is realised that the city, apart from being a pre-colonial origin with a large area of land covering approximately 35,743km squares (Odunaike et al., 2007), it also shares boundary with kwara state to the north, Osun state to the south and partly Ogun state and partly Republic of Benin to the west with a rich agricultural land for production of raw materials. This has made the metropolis a market place for cocoa, kola, cassava and other local agricultural products, hence making the city Cosmopolitan (Akinloye & Olomo, 2005).

As a result of the availability of raw material located in the city, this sprung up the influx of several industrial establishments especially in the area of food, chemical, plastic, electronics and tobacco. This event has widened the spectrum of economic and commercial development in the city and the state at large through the production of goods and consumables. With this there is increase in industrialization which also helps in reduction of unemployment in the state. But the story is different in that the increase in industrialization has caused disruption in the environmental ecosystem in those region or site of operation of these Industries. This constituted a threat to human beings and other micro-organism in the area of study (Odunaike, 2008).

However, the hazard posed by the industries are not only in term of production of toxic waste, heavy carbon-monoxide smoke to the atmosphere and odour from the waste product from those industries (Jibiri et al., 2007). But may arise from electromagnetic radiation or wave emanating from such industries. Since, there was a report that some chemical and industrial machinery are capable of emitting some certain amount of electromagnetic wave (Archibong and Chiaghanam, 2020). This however aroused our interest to assessing the radiation emission levels at these selected industrial sites in the area of study to provide data as part of radiation monitory research. This is for proper assessment of radiation exposure of the workers, resident and the entire population of the metropolis in comparison to the international recommendation by United Nation Scientific Committee on Effect of Atomic Radiation (UNSCEAR).

Although, several works have been done in assessment of radiation emission levels at this study area and nearest location examples are Background radiation level in dumpsite (Ademola, 2008), The radioactivity in some grasses in the environment of Nuclear Research Facility (Akinloye & Olomo, 2005) etc. However, radiation emission level from industrial sites is still yet unknown, hence seen as a loop hole in the body of existing knowledge of radiation protection.

The following procedure was employed for this study:

### *Survey Meter*

RADOS-30 was used for this study. It is specific in detection of Gamma and X-ray with energy ranged from 48keV-1.3MeV. It uses battery for power supply. It is manufactured by RADOS Technology in Finland.

### *Study Area*

The study area was located at Oluyole local government area of Ibadan. The city of Ibadan is located is south-western Nigeria, 128 kilometers (80 miles) inland northeast of Lagos and 530kilometres(330miles) southwest of Abuja, the federal capital and is a prominent transit point between the coastal region and the areas in the hinterland of the country. Until 1970, Ibadan was the largest city in sub-Saharan of African surface. In 1952, it was estimated that the total area of the city was approximately 103.8km$^2$. However, Areola, (1994) estimated that by year 2000, Ibadan would cover about 400km$^2$. Ibadan city comprises of 11 L.G.A of Oyo state.

For the purpose of this study, Oluyole L.G.A which is one of the largest areas of Ibadan was considered due to its high industrialization therein. It has a population of 202,725 at the 2006 population census. Its GPS Coordinates are 7.23333° N, 3.86667° E. It is the industrial hub of Ibadan with occupancy of different industries that produces a lot of goods like beverage, food drink, plastic etc. which has contributed to the social-economic advancement in the study area.

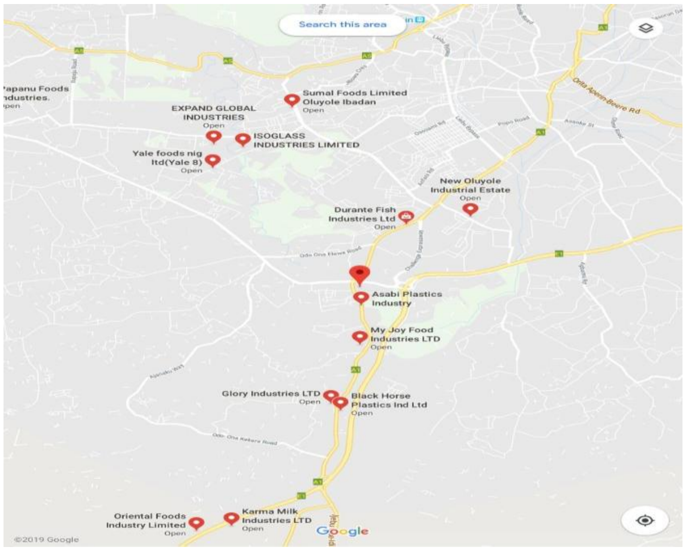

Fig.1: Map of the Study Area (www.googlemaps.com)

### *Sampling Procedure*

The exposures to radiation were determined from ten industries within the study area with the RDS-30 for detection and quantification of Gamma and X-radiation. A survey reading was taken for each background emission levels at distance of 25-30metres away from each of the industries to eradicate interference of the background emission levels with the actual dose rate from the industries. The radiation survey meter is switch on and placed about 1metre above the ground level at the gonad and it measured absorbed dose in micro-Sievert per hour (µSvhr$^{-1}$). Three readings were taken at the highest stable point and recorded each for the ten industries.

## II. RADIOLOGICAL HAZARD INDICES

I. The exposure **(D)** measured in µSvhr$^{-1}$ from the meter was converted to annual absorbed dose rate **(ADR)** in mSvyr$^{-1}$ according to equation 1.0( Etuk, *et al.*, 2015)**ADR** (mSvyr$^{-1}$) = D X OF X 24hrs X 365.25days X 10$^{-3}$...........................Eq (1)

II. The Annual Effective Dose Rate **(AEDR)** per year received by the workers and the population of the study area was obtained from equation 2.0 (UNSCEAR, 2000).**AEDR** (mSvyr$^{-1}$) = D X 8790hrs X CF X OF X 10$^{-3}$.......................Eq (2).

III. The Excess Lifetime Cancer Risk (ECLR) is calculated from equation 3.0 (Taskin, *et al.*, 2009). ECLR = AEDR X DL X RF............................................Eq (3).

**D =** dose rate of exposure in µSvhr$^{-1}$.

**OF =** Occupancy factor is the expected period members of the population would spend within the study area. It is 0.2, for it is expected that human being would spend 20% of the time outdoors.

**CF** = Conversion factor of the absorbed dose in air to the effective dose which is equal 0.7

**DL** = Duration of Life (assumed to be spent by individual which is equal 70years)

**RF** = Risk factor is the fatal cancer risk per Sievert for stochastic effect which was given International Commission on Radiation Protection (ICRP 60) recommended RF = 0.05 for the public (Taskin, *et al.*,2009).

## III. RESULTS

The results of the measurements of the radiation levels at the production sites of the different industries and the background radiation levels using the survey meter (RADOS-30) are presented in tables 1 and 2.

Table 1: Mean radiation levels at the production sites of the industries.

| Equivalent dose levels at different locations at the production sites (µSv/hr) | | | | | Mean Equivalent dose levels at each industry | Mean background radiation levels |
|---|---|---|---|---|---|---|
| Industries | 1 | 2 | 3 | 4 | µSv/hr | µSv/hr |
| A | 0.15 ± 0.016 | 0.18 ± 0.016 | 0.16 ± 0.013 | 0.16 ± 0.013 | 0.16 ± 0.011 | 0.10 ± 0.04 |
| B | 0.10 ± 0.014 | 0.18 ± 0.013 | 0.13 ± 0.008 | 0.15 ± 0.009 | 0.14 ± 0.029 | 0.09 ± 0.03 |
| C | 0.12 ± 0.005 | 0.14 ± 0.009 | 0.11 ± 0.009 | 0.11 ± 0.008 | 0.12 ± 0.012 | 0.08 ± 0.01 |
| D | 0.13 ± 0.008 | 0.15 ± 0.005 | 0.14 ± 0.009 | 0.14 ± 0.008 | 0.14 ± 0.007 | 0.10 ± 0.02 |

| | | | | | | |
|---|---|---|---|---|---|---|
| E | 0.11 ± 0.014 | 0.15 ± 0.016 | 0.12 ± 0.014 | 0.14 ± 0.005 | 0.13 ± 0.016 | 0.09 ± 0.03 |
| F | 0.10 ± 0.008 | 0.13 ± 0.009 | 0.10 ± 0.005 | 0.11 ± 0.008 | 0.11 ± 0.012 | 0.07 ± 0.02 |
| G | 0.11 ± 0.005 | 0.16 ± 0.008 | 0.12 ± 0.005 | 0.13 ± 0.008 | 0.13 ± 0.019 | 0.08 ± 0.03 |
| H | 0.16 ± 0.005 | 0.25 ± 0.008 | 0.21 ± 0.008 | 0.18 ± 0.009 | 0.20 ± 0.034 | 0.09 ± 0.02 |
| I | 0.14 ± 0.009 | 0.16 ± 0.016 | 0.15 ± 0.008 | 0.15 ± 0.005 | 0.15 ± 0.007 | 0.08 ± 0.03 |
| J | 0.13 ± 0.008 | 0.16 ± 0.005 | 0.14 ± 0.005 | 0.13 ± 0.005 | 0.14 ± 0.012 | 0.09 ± 0.03 |

Table 1 presents the equivalent dose levels measured at the different locations of production sites of the different industries. Location 1 corresponded to the entrance of the production house, location 2 corresponded to the back of the production house while locations 3 and 4 corresponded to the left and right sides of the production house. The equivalent dose level was highest at Location 2 (the back of the production house) and lowest at location 1 (the entrance into the production house) for all selected industries. The mean equivalent dose levels ranged from 0.11μSvhr$^{-1}$ at Industry F to 0.20μSvhr$^{-1}$ at Industry H with a mean of 0.14μSvhr$^{-1}$.

Table 1 also showed the background radiation levels measured 25 – 30 metres from the production house of the industries. The background radiation level ranged from 0.07μSvhr$^{-1}$ around Industry F to 0.10 μSvhr$^{-1}$ around industries A and D with a mean of 0.087μSvhr$^{-1}$.

Table 2: Annual equivalent dose rates, absorbed dose rate, annual effective dose equivalent and excess lifetime cancer risk at the different industries

| Industries | $^{a}D_0$ nGyhr$^{-1}$ | $^{b}HT_{ann}$ mSvyr$^{-1}$ | $^{c}$AEDE mSvyr$^{-1}$ | $^{d}$ECLR x $10^{-3}$ |
|---|---|---|---|---|
| A | 160 | 0.28 ± 0.04 | 0.20 ± 0.05 | 0.70 |
| B | 140 | 0.25 ± 0.05 | 0.17 ± 0.04 | 0.60 |
| C | 120 | 0.21 ± 0.03 | 0.15 ± 0.06 | 0.53 |
| D | 140 | 0.25 ± 0.06 | 0.17 ± 0.05 | 0.60 |
| E | 130 | 0.23 ± 0.04 | 0.16 ± 0.07 | 0.56 |
| F | 110 | 0.18 ± 0.03 | 0.12 ± 0.04 | 0.42 |
| G | 130 | 0.23 ± 0.06 | 0.16 ± 0.03 | 0.56 |
| H | 200 | 0.35 ± 0.05 | 0.25 ± 0.05 | 0.90 |
| I | 150 | 0.26 ± 0.05 | 0.18 ± 0.04 | 0.63 |
| J | 140 | 0.25 ± 0.05 | 0.18 ± 0.04 | 0.63 |

$^{a}D_0$ - Absorbed dose rate; $^{b}HT_{ann}$ - Annual equivalent dose rate; $^{c}$AEDE - annual effective dose equivalent, $^{d}$ECLR - excess lifetime cancer risk

Table 2 depicts the calculated values of absorbed dose rate ($D_0$), Annual equivalent dose rates ($HT_{ann}$), annual effective dose equivalent (AEDE) and excess cancer lifetime risk (ECLR) at the production sites of the different industries obtained from equations 1, 2, 3 and 4. It can be seen from table 2 that the values of AEDE and ECLR increased with increase in the values of $D_0$ and $HT_{ann}$. The values of $D_0$ and $HT_{ann}$ ranged from 110nGyhr$^{-1}$ and 0.18mSvyr$^{-1}$ at Industry F to 200nGyhr$^{-1}$ and 0.35mSvyr$^{-1}$ at Industry H with mean of 142nGyhr$^{-1}$ and 0.25mSvyr$^{-1}$ respectively. Also, the mean AEDE and ECLR values for the ten industries were 0.17mSvyr$^{-1}$ and 0.61 x $10^{-3}$ while the values of AEDE and ECLR ranged from 0.12mSvyr$^{-1}$ and 0.42 x $10^{-3}$ at industry F to 0.25mSvyr $^{-1}$ and 0.90 x $10^{-3}$ at Industry H respectively.

## IV. DISCUSSION

The mean background radiation level measured 25 – 30 metres away from the ten industries is 0.087μSvhr$^{-1}$. This is similar to the value of 0.09μSvhr$^{-1}$ reported by (Odunaike et al, 2009) on the background radiation level in refuse dumps across Lagos metropolis, Southwestern Nigeria. This value is low when compared with the value of 0.9mSv recommended for external exposure by (UNSCEAR, 2000). The lower background radiation level maybe due to the geology and altitude of Oluyole local government area (Nwankwo and Akoshile, 2005).

The mean equivalent dose rate for the ten selected industries was 0.14μSvhr$^{-1}$ and ranged from 0.11μSvhr$^{-1}$ to 0.20μSvhr$^{-1}$. These values were high compared to the mean background radiation level and this implies that there has been an increase in the radiation levels of the working environments due to presence of these industries. This increase in radiation levels at the production sites may be due to the type of raw materials used for production as increased levels of background radiation may be associated with certain natural materials, minerals and other resources used as raw materials in industries (Ademola and Olatunji, 2013; Lu and Zhang, 2006). Also, the effluent materials generated during and after production processes may contain a higher number of radionuclides and again the waste management system may not be good enough leading to the higher radiation levels.

The absorbed dose is used to assess the potential for any biochemical changes in specific tissues. It quantifies the radiation energy that might be absorbed by a potentially exposed individual[1]. The mean absorbed dose rate ($D_0$) for the ten industries is 142nGyhr$^{-1}$ and ranged from 110nGyhr$^{-1}$ to 200nGyhr$^{-1}$. This is similar to the value of 141.30nGyhr$^{-1}$ reported by (Agbalagba, 2017) for Warri city in Delta State but higher than the value of 132.16nGyhr$^{-1}$ reported by (Agbalagba, 2016) for Ughelli metropolis in Delta State, Nigeria. According to (Chiaghanam et al, 2019), they reported the radiation risk assessment of soil in Idomi, Cross-river, Nigeria. In their work on soil sample, the calculated absorbed gamma dose from the sample was 110.31nGyyr$^{-1}$. The $D_0$ value in this study is higher than the recommended safe limit value of 84nGyhr$^{-1}$ by UNSCEAR 2008. The implication of this high $D_0$ is a radiation contaminated environment and constitute a potential for long-term health hazards in the future due to accumulated doses (Agbalagba, 2016).

The annual effective dose equivalent is used to assess the potential for long-term effects that might occur in the future. The mean AEDE level for all the ten industries was 0.17mSvyr$^{-1}$. This mean annual effective dose is higher than world average value of 0.07mSvyr$^{-1}$ (UNSCEAR, 2008; ICRP, 2007); but falls within the recommended permissible dose limits of 1.00 mSv$^{-1}$yr for the general public by ICRP and UNSCEAR (UNSCEAR, 2008; ICRP,2007). This implies that the studied environment is radiation contaminated due to the activities of the industries in the area but the contamination does not constitute any immediate radiological health effect as it is within permissible limit (Agbalagba, 2016).

The excess lifetime cancer risk is used to predict the probability of an individual developing cancer over his lifetime due to low radiation dose exposure, if it will occur at all. The mean excess cancer lifetime risk (ECLR) for the ten industries was 0.60 x $10^{-3}$. This value is similar to the value of 0.541 x $10^{-3}$ reported by (Agbalagba, 2016) in Emene industrial layout in Enugu state, Nigeria. The mean ECLR value for this study is higher than the recommended limit of 0.29 x $10^{-3}$ given by UNSCEAR (UNSCEAR, 2000). The higher ECLR value implies that there is a possibility of cancer development by residents who wish to spend all their life time in the area (Agbalagba, 2016). Again, this value would inform the workers and residents about risk associated with long stay in the industrial vicinities.

## V. CONCLUSION

This study assessed the radiation levels at the production sites of ten industries in Oluyole local government area of lbadan city Oyo state, Nigeria. It can be concluded from this study that though the radiation levels at the industrial sites were below the permissible limit of 1mSv, the industrial environment was radiation contaminated with a possibility of health hazards on residents that wish to spend all their life time in the area.

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