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Assessment on Radiation Hazard Indices from Selected Dumpsites in Lafia Metropolis, Nasarawa State, Nigeria

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ABSTRACT

This research reports an assessment of ionizing radiation in some chosen Dumpsites in Lafia Local government area of Nasarawa State. Ionizing radiation measurement was conducted at four Dump sites. The survey was done using a radiation survey meter (Radex one Outdoor 55130719 NA). Radiation exposure rate in micro sievert per hour (μSvhr^{-1}) was measured. Readings were taken by placing the detector at gonad level about 1 meter above the ground. Result showed that the average annual effective dose rate in the selected dumpsites were 0.22 mSv/yr for Lafia modern market, 0.17 mSv/yr for dumpsite opposite governor Isa house, 0.15 mSv/yr for Timber shade Lafia and 0.20 mSv/yr for Science School Lafia respectively with a mean value of 0.19 mSv/yr for all location, while the mean calculated excess life cancer risk (ELCR) is 0.65×10^{-3} . Dumpsites yearly absorbed dose rate and their corresponding ELCR values did not exceed the 1.0 mSv/y Basic Safety Standard set for the masses by International Council on Radiation Protection (ICRP, 1999) and mean world average ELCR value of 1.16×10^{-3} . Based on these results there are no radiation consequence to the scavengers, dumpsite workers and residents living around the dumpsites.

1. Introduction

Radiations are categorized into two types, which are, the ionizing and non-ionizing radiation. Ionizing radiation is the type of radiation which has the energy that is sufficient enough to strike an electron out of its orbits around atom, altering the electron/proton ratio and making the atom positively charged. Molecules and

atoms which are electrically charged are called ions. Ionizing radiation includes those radiations which come from both natural and artificial radioactive materials^[1]. Examples of ionizing radiations are alpha particles and beta. Alpha particles are made up of two protons and two neutrons each and that carry a double positive charge. Beta particle consists of charged particles that are ejected from an atom's nucleus and that are physically identical to

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electrons. Non-ionizing radiation is the type of radiation which does not possess sufficient energy compared to ionizing radiation; the energy it possesses is not sufficient enough to liberate an electron from an atom. It can only excite the atom. Background radiation is radiations that could occur as a result of natural sources of radiation such as cosmic radiations (sun), terrestrial radiation (soil) and internal radiation (potassium – 40 and carbon – 14 inside the body) ^[2,3].

Naturally-occurring background radiation is the major source of getting exposed to radiation for most of the population. The Basic Safety Standard for workers has been recommended to be 20 mSv/yr, while that of public is about 1 mSv/yr ^[4].

Ionizing radiation can also be generated as a result of medical, commercial and industrial activities. The most familiar and, in national terms, the largest of these sources of exposure is medical X-rays. Literature has it that natural radiation contributes almost about 88% of the annual dose to the population and medical procedures most of the remaining 12%. Natural and most of the artificial radiations are not different in kind or effect ^[5].

Most of the differences in getting exposed to natural background radiation are as a result of inhalation, ingestion and direct contact of radioactive gases such as Radon which are produced by radioactive minerals found in soil and bedrock. Radon is an odorless and colorless radioactive gas that is produced from the decay of Radium. Radium is a radioactive gas produced from the decay of Thorium. Thorium is a radioactive gas produced from the decay of Uranium. Radon and Thorium levels are varying considerably by location depending on the composition of soil and bedrock ^[6-8].

Once these gases are released into the air, they always get diluted to their harmless levels in the atmosphere even though, most times they become trapped and accumulate in our buildings and later inhaled by occupants of those buildings ^[9]. Radon gas causes some health risks not only to illegal miners, but also to home owners if it is allowed to enter into our various homes. On average, it is the largest source of natural radiation exposure ^[10,11].

Exposure to radiation carries a lot of health risks and Understanding the risks helps the CNSC and other regulatory bodies establish dose limits and regulations that keep exposure at an acceptable or tolerable risk level, where it is unlikely to cause harm ^[12-15].

Waste can be defined as unwanted and unusable materials and is considered as a substance that cannot be used any longer. Dump sites are piece of land where waste materials are dumped like dry waste, e-waste, plastics, scraps metals, broken glasses among others. Waste is

generally classified as Industrial waste, commercial waste, domestic waste, and agricultural sources of waste. In dumpsites, waste is commonly classified as biodegradable that is those that can decompose (organic waste) and non- biodegradable waste that is those that do not decompose (inorganic waste). Based on IAEA categorization of radioactive waste, wastes from dump sites can be classified as very low-level waste (VLLW) called naturally occurring radioactive material (NORM) waste though they may not be harmful to humans or the environment but studying the level of background radiation in dumpsites could provide essential radiological information in an environment ^[16].

Wastes made up an environmental and public health nuisance in major cities all over the world. Thus, governments regard waste management as vital social service whose budgetary provision is made in line with population projections ^[17]. Hazards caused by such dumpsite are not only in term of odor and presence of disease causing microorganism, but can arise from the radiation emanating from such dumpsite ^[18]. Various radioactivity measurements have shown the existence of traces of radionuclide in books ^[19] and in the staple food consume in Nigeria ^[20]. It has also been established that vegetation and environmental fields in Nigeria contain traces of radioisotopes. All these, are contained in the domestic waste which are indiscriminately dumped on open fields, farms soils, Quarry sites, rivers, well and boreholes, industries and even on road sides and mechanic workshops ^[21]. In addition, industrial wastes that are liable to contain traces of radionuclide are also dumped indiscriminately. Consequently, the radioisotope content in the waste dumpsite, if not properly managed emits mixed radiation to the environment ^[22]. Emission of radiation categorization of waste dumpsites ^[23] and measurement of background radiation in refuse dumps ^[24] shows the level and long term effects of these radiations if not properly monitored. The 2011 Fukushima Daiichi nuclear disaster displaced thousands of people and its effects is still being felt even in places far from the site ^[25].

The regulatory bodies that are saddled with providing limits on background radiations includes the National Council on Radiation Protection and management (NCRM), United Nations Scientific Committee on the Effect of Atomic Radiation (UNSCEAR) Nigeria Nuclear Regulatory Authority (NNRA), Radiation Protection Regulation, (RPR) and international commission on Radiation Protection (ICRP) among others. According to ICRP recommendations, the limit of exposure to the public should not be more than 1mSv/yr ^[26].

Waste disposal and its successful management

is a global challenge, with the continuous increase in population in Nasarawa State due to increase in commercial businesses, educational institutions, industries amongst other, Lafia and its environ is not left out of this growing concern as waste disposal has also increased which could lead to increase in background radiation and invariably leading to increase in human radiation exposure because of the concentrations of ⁴⁰K, ²²⁶Ra and ²³²Th in the soil and waste materials or because of internal inhalation of radon and its progenies in dust and fumes from waste disposal sites [27-29].

There are four major dumpsites in Lafia which contains the biodegradable and non- biodegradable wastes. Although, the waste according to IAEA are classified as NORM and may not be harmful to human or environment, the level of background radiation could be more than that stipulated by ICRP. The literature reviewed showed no data on the level of background radiation in the selected sites, therefore the aim of this study is to assess the background radiation level from some selected dump sites located in Lafia Metropolis, Nasarawa State through the following objectives by measuring the absorbed dose rate in micro sievert per hour from the selected dumpsites in Lafia metropolis and using the measured result to compute the annual effective dose rate from the chosen dumpsites in Lafia metropolis and the associated excess lifetime cancer risk as a result of the exposure.

Therefore, proper time to time checking and estimation of the radiation level emanating from dumpsites in order to give accurate data as part of environmental monitoring research for effective assessment of radiation exposure rate of the metropolis motivated this study.

The results obtained from this work will allow for the estimation of excess life cancer risk of persons living close to the dumpsites. Data obtained from this work could be used as a reference baseline radiometric data for future research on background radiations in the selected areas. This could be used as a yard stick for evaluating the extent of any pollution in the environment due to any accidental release of radionuclide. The result gotten from this work could also be a sort of guide to the Lafia waste management body in setting up safety waste management protocols.

2. Materials and Method

2.1 Materials

The materials used in this research include;

- i. Inspector alert Nuclear Radiation Monitor RADEX ONE Outdoor (Radioactivity indicator) with the serial

number 55130719 NA (manufactured by OOO Quarto-Rad) used to measure ambient ionized radiation types of beta, Gamma and products, as well as the accumulated radiation dose received.

- ii. Global Positioning System (GPS): The GPS (Global positioning system) mobile application was used to take all location data.

2.2 Method

2.2.1 Sample Location

The study was carried out in Lafia the capital of Nasarawa state, the area for which study was carried out is a Cosmo-political, heavily populated area of Lafia. The dumpsites are located in the communities with a various number of scavenger’s sources for the daily recycling of waste. The site, location of dumpsites, waste found in the dumpsites as well as their respective GPS coordinate are tabulated below:

Table 1. Description of Dumpsite

S/ N	Site Name	Location of the Dumpsite	Waste Found	GPS Coordinate	
				North	East
1	Lafia modern Market)	The dump site is situated close to the exit gate of the market site	Rotten food, vegetables, nylon, glasses, and irons	8°29'31	8°31'44
2	Opposite governor Isa house Tudun kauri	The dump site is located along Markurdi road	Irons, food waste, glasses, nylons and electronics waste	8°29'8	8°31'53
3	Timber shade Lafia	The dump site is located along U.A.C road inside Lafia timber processing factory	Timber waste	8°29'51	8°30'49
4	Science School Lafia	The dump site is located behind the fence of science school Lafia.	Nylons, food waste, irons, electronics waste, and rotten vegetables	8°30'11	8°30'45

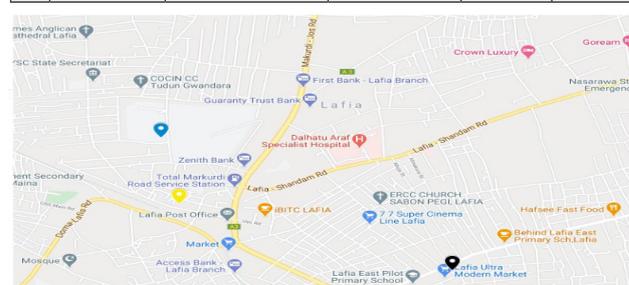


Figure 1. Map of Sample Locations

2.2.2 Method Data Analysis

The detector that was used to measure the exposure level in the field was a well calibrated, sensitive and portable radiation survey meter with serial number 55130719 NA having a Geiger Muller tube that has the ability of detecting Alpha, Beta, Gamma and X-rays. Readings were taken from ten (10) different locations in each of the four dumpsites to spatially reflect the sites, while a global positioning system (GPS) was used to take the coordinates of sample points. Data were collected three times in a week in each of the dumpsites for four weeks (1 month, March/April 2020) and the average values were obtained. Data were obtained between the hours of 11.00 am and 4:00 pm each day. The tube of the radiation meter was placed at a height of 1 m above the ground with its window facing first the Dumpsites and then vertically downward. The detector was switched on to absorb radiation for a few seconds and the highest stable point was recorded. This was converted to annual effective dose rate in milli Sievert per year (mSvyr⁻¹). The result obtained was used to calculate the ELCR using Equations 1 to 3.

$$\text{Absorbed dose in air, D (nGy/hr)} = \text{Exposure in air, E } (\mu\text{Sv/hr}) \times 1000 \quad (1)$$

$$\text{AEDR (mSv/yr)} = \text{absorbed dose in air (D) (nGy/hr)} \times 8760\text{hr/yr} \times \text{O.F} \times \text{C.C} \quad (2)$$

$$\text{ELCR} = \text{AEDE(mSv/yr)} \times \text{DL} \times \text{RF} \quad (3)$$

Where

8760hr/yr = the total hours per year.

0.2 = outdoor occupancy factor (OF) for outdoor radiation.

0.7 = the conversion coefficient (CC) (Sv/yr).

D= Annual absorbed dose rate in micro sievert per year.

ELCR- excess lifetime cancer risk

AEDR- annual effective dose rate

DL- average duration of life (70 years)

RF- risk factor (0.05 Sv⁻¹)

3. Results and Discussion

3.1 Results

The aim of this study was to assess the level of background radiation from some selected dump sites located in Lafia Metropolis, Nasarawa State. Tables 2 to 5 show the average values of absorbed dose rate in $\mu\text{Sv/hr}$ for morning and evening readings in the selected locations. While Table 6 shows the summary of radiological hazard indices that is the annual effective dose rate in mSv/yr and Excess Life Cancer Risk in the

selected dumpsites. These values were calculated from the average values of absorbed dose rate in $\mu\text{Sv/hr}$.

Table 2. Absorbed Dose Rate in $\mu\text{Sv/hr}$ in Lafia Modern Market

Lafia Modern Market				
Week	GPS Coordinate		Absorbed Dose ($\mu\text{Sv/hr}$)	
	North	East	Morning	Afternoon
1	8°29'31.383	8°31'44.474	0.20	0.21
2	8°29'31.439	8°31'44.330	0.21	0.18
3	8°29'31.490	8°31'44.446	0.16	0.17
4	8°29'31.507	8°31'44.488	0.14	0.14
Average			0.18	0.18

Table 3. Absorbed Dose Rate in $\mu\text{Sv/hr}$ at Dumpsite Opposite Governor Isa House, Tudun Kauri, Lafia.

Opposite Governor Isa House				
Weeks	GPS Coordinate		Absorbed Dose ($\mu\text{Sv/hr}$)	
	North	East	Morning	Afternoon
1	8°29'8.532	8°31'52.327	0.17	0.10
2	8°29'8.690	8°31'52.801	0.16	0.12
3	8°29'8.843	8°31'52.403	0.15	0.14
4	8°29'8.620	8°31'52.300	0.11	0.17
Average			0.15	0.13

Table 4. Absorbed Dose Rate in $\mu\text{Sv/hr}$ at Dumpsite in Timber Shade, Lafia.

Timber Shade Lafia				
Weeks	GPS Location		Absorbed Dose ($\mu\text{Sv/hr}$)	
	North	East	Morning	Afternoon
1	8°29'51.329	8°30'49.239	0.10	0.13
2	8°29'8.391	8°31'52.233	0.12	0.10
3	8°29'51.321	8°31'52.975	0.14	0.12
4	8°29'51.425	8°31'52.874	0.13	0.14
Average			0.12	0.12

Table 5. Absorbed Dose Rate in $\mu\text{Sv/hr}$ at Dumpsite in Science School Lafia.

Science School Lafia				
Weeks	GPS Location		Absorbed Dose ($\mu\text{Sv/hr}$)	
	North	East	Morning	Afternoon
1	8°30'11.481	8°30'45.344	0.20	0.16
2	8°30'11.765	8°30'45.543	0.18	0.15
3	8°30'11.590	8°30'45.216	0.15	0.14
4	8°30'11.763	8°30'45.195	0.14	0.16
Average			0.17	0.15

Table 6. Radiological Hazard Indices for the Four Selected Dumpsites in Lafia Metropolis.

S/ N	Location	Average dose rate (μSv/hr)	Mean dose rate. D (nGy/hr)	Annual effective dose rate (mSv/yr)	ELCR x 10 ⁻³
1	Lafia modern market	0.18	180	0.22	0.77
2	Opposite governor Isa house	0.14	140	0.17	0.59
3	Timber shade Lafia	0.12	120	0.15	0.53
4	Science School Lafia	0.16	160	0.20	0.70
	Average	0.14	150	0.19	0.65

3.2 Result Analysis

The collected data were analyzed using excel spread sheet. Graphs were plotted using origin 5.0 to enable vivid comparison of results with other works and that of standard organizations.

Figure 2 shows a plot of average values of radiological hazard indices from the selected Dumpsites compared with the values of related works of other authors and that of international regulation UNSCEAR.

From Figure 2, the annual effective dose rate and Excess Life Cancer Risk (ELCR) values of this work when compared with other authors work shows that the values were higher than the work of [9] while the AEDR and ELCR values were lower when compared with the work of [30].

However, from the values of radiological hazard

indices obtained in this work and related works; the annual effective dose rate (AEDR) was below the world standard of 1mSv/yr (ICRP) and excess life cancer risk (ELCR) was also below the world standard of 1.16×10^{-3} except Awwiri and Esi, whose values were higher than the world standard.

3.3 Discussion

In this work, the minimum value of absorbed dose rate from the four selected dumpsites is 0.12 μSv/hr in Timbre Shade, while the maximum value is 0.18 μSv/hr in Lafia Modern Market. These values were calculated using the average values from Table 2 to Table 5. The total average value of the absorbed dose rate for the four selected site was found to be 0.14 μSv/hr.

The annual effective dose rate was calculated using Equation (2) and an average value of 0.19mSv/yr was found for all the selected dump sites with a minimum average value of 0.15 mSv/yr in Timbre Shade and an average maximum value of 0.22 mSv/yr in Lafia Modern Market. The Excess Life Cancer Risk (ELCR) which is the possibility of getting cancer resulting from life time exposure to background radiation was calculated from the average value of AEDR using Equation 3 The ELCR values ranges from 0.53×10^{-3} to 0.77×10^{-3} with a total average value of 0.65×10^{-3} as shown in Table 6.

4. Conclusions

The estimation of ionization radiation in four dumpsites

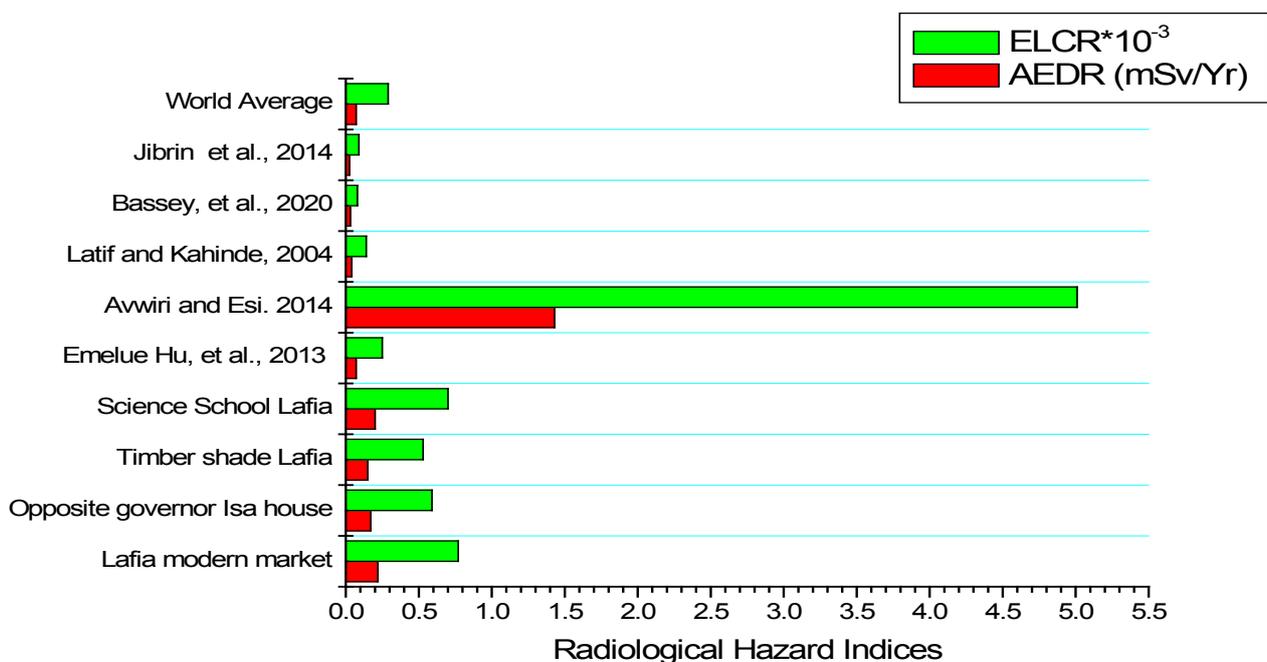


Figure 2. Values of radiological hazard indices in this work, related works and world average.

in Lafia Local government area of Nasarawa State, Nigeria was carried out. The mean average background radiation exposures in the selected dumpsites were lower than the normal background standard of $0.39\mu\text{Sv/hr}$. The computed annual absorbed dose rate obtained results are also lower than the ICRP dose limit of 1.0mSv/yr for the general public (ICRP, 1999). The corresponding estimated average ELCR of 0.65×10^{-3} were also lower than the normal background standard of 1.16×10^{-3} .

4.1 Recommendations

It is recommended that waste material should be adequately sorted out before disposing into the dumpsites. There should be regular monitoring/inspection of radiation levels in these environments by the government. More so, dumpsite workers should operate shift system, and lastly Environmental Health Officer should also assist to ensure that all activities within the selected areas are within environmental standard.

4.2 Suggestion for Further Studies

Further research should be carried out on soil sample analysis at the same location to know the specific radionuclide elements contributing to the background radiation in the area and their degree of contribution.

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