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Assessment on Radiation Hazard Indices from Selected Dumpsites in Amassoma Bayelsa State, Nigeria

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ABSTRACT

This research reports an assessment of ionizing radiation in some selected Dumpsites in Amassoma Bayelsa State, Nigeria. Ionizing radiation measurement was conducted at fifteen (15) Dump sites. The survey was achieved using a factory calibrated Inspector Digilert 100 Nuclear radiation meter (SN:35440, by SE International, Inc., USA). The meter's sensitivity is $3500\ CPM/(mRh^{-1})$ relative to Cs-137, and its maximum alpha and beta efficiencies are 18% and 33%, respectively. Readings were taken by placing the detector at gonad level about 1 meter above the ground. The result showed that the mean average radiation obtained values in all the dumpsites ranged from $0.067\mu Svh^{-1}$ to $0.137\mu Svh^{-1}$, with a mean value of $0.962 \pm 0.715\mu Svh^{-1}$ which is higher than the normal background standard of 0.013mR/h. The computed equivalent dose rate obtained results $0.563\ msvy^{-1}$ to $1.152\ msvy^{-1}$ with a mean value of $0.809 \pm 0.147\ msvy^{-1}$, for the study area. The computed equivalent dose rate of the study area is below the standard permissible limit of $1.0\ msvy^{-1}$ for the public and is below the dose limit of 1.0mSv/yr for the general public and far lower than dose limit of 20.0mSv/yr for the general public (ICRP, 1999). The results of the absorbed dose rate has a mean of $83.694 \pm 15.209\ nGyh^{-1}$ in the study area is greater than the permissible level of $59nGyh^{-1}$, while the overall mean of annual equivalent dose rate of $0.103 \pm 0.187mSvy^{-1}$ is below the recommended standard value. The excess lifetime cancer risk (ELCR) computed from the study area has a mean value of $0.340 \pm 0.066\mu Svy^{-1}$ which is greater than the world average value. These reported values may indicate no immediate radiological health hazards, but may cause long-term health hazard to the occupants, workers and residents of the studied community due to increase with longer period of operation.

1. INTRODUCTION

The ever-increasing exposure of man to ionizing radiation in his environment both from natural sources such as radon, thorium, and uranium and from artificial sources such as medical waste and X-rays etc cannot be overemphasized. Study has vividly shown over the years, that the environment can be considered also as a house to natural

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radioactivity which are accumulated in the air, soil (through the activities of rainfall, flooding and erosion) and the earth naturally. The contributions from these components resulting to the spread or availability of background radiation within any locality vary with local geology, altitude and geomagnetic latitudes. Activities like gas and oil exploitation as well as mining of solid minerals augment the natural sources. The concentration and gamma radiation from the radioactive nuclides vary significantly, depending on the geological and geographical features of the region (Sharma et al., 2017). The use of radiation sources in medical diagnosis and therapy, nuclear weapons, nuclear power plants, fertilizers production, research institutions as well as in consumers products have contributed to increase in background radiation exposure and doses.

Radiation may be defined as the emission and propagation of energy in the form of rays or waves from the atoms and molecules of a radioactive substance because of nuclear decay. The ionizing radiation from natural sources that humans are exposed to almost all the time is called natural background ionizing radiation (BIR). Background radiation depicts the ionizing radiation present in the environment at a particular geographical location, which is not a result of the deliberate introduction of radiation sources. The activities of man carried out in every aspect of life, results in the production and availability of waste found in the environment. So therefore, waste arguably is one of the substance or material readily available or found everywhere in the environment. Although there are natural contributing factors to the presence of waste found in the environment, but the contribution of man is very high.

Waste dumpsites in most environs in Nigeria, apart from been regarded as a serious threat to the environment, can also be detrimental to the health of the populace. Nevertheless, the hazards posed by the dumpsites situated in the environment, do not only result to the production of offensive odors and disease producing microorganisms, but can also arise from the radiation emanating from the dumpsites. Ugwuanyi et al., (2021) carried out research on the background radiation levels in selected dumpsites in Nnewi community setting, Southeast Nigeria and ascertain that the radiation levels emitted from the study area were within permissible limits for the general population. Therefore, there is little risk of instantaneous radiation hazard with an estimated safety zone at 6 meters from the dumpsites. Odunaike et al., (2008) investigated radiation emission characterization of waste dumpsites in the city of Ibadan in Oyo State of Nigeria and said that the results of the investigation revealed that the mean annual dose rate from the waste dumpsites in the city is $26.2\mu Svyr^{-1}$ which is far lower than the average of $70\mu Svyr^{-1}$ put forward by United Nation Scientific Committee on Effect of Radiation. Thus, there should be no fear of serious health hazards due to the exposure level of the emitted radiation of the entire populace of the city of Ibadan. However, focus should be on the proper management of the waste generated in the city to prevent outbreak of diseases and better improve the environment and conserve natural resources.

Owing to the increasing of commercial and industrial activities around Amassoma, both in the private and public sectors with the aim to create employment and diversified economy, there have been many activities resulting in the disposal of wastes of different classes within the environment. There are regulations guiding the disposal of all classes of waste, but little or no attention has been paid to them both in the private and public sectors and the result of this negligence has created room for the presence of unauthorized dumpsites in Amassoma. Usikalu et al., (2017) on the measurement of background radiation dose from selected dumpsites in Ota and its environs stated that all the estimated parameters were higher than the permissible limit set for background radiation for the public. Conclusively, the associated challenge and radiation burden posed by the wastes on the studied locations and scavengers are high. Therefore, there is need to investigate the way and how waste can be properly managed to alleviate the effects on the populace living and working in the dumpsite's vicinity. Jibri et al., (2014) carried out research on assessment of radiation exposure levels at Alaba e-waste dumpsite in comparison with municipal waste dumpsites in southeast Nigeria and reported that the main absorbed dose rate at the e-waste dumpsite was $22.12 nGy/h$ which is lower than the world average and lower than their respective minimum permissible limits. Hence, e-waste and municipal waste does not pose any immediate radiological risk to the people working/living in the vicinity of the dumpsites.

Health and safety concerns associated with waste generated at dumpsites are thus; inhalation of toxic and heavy metals (from Pb, Cd, Hg etc.), contamination and pollution of soil and groundwater and potential exposure to radiation from ashes, smoke, dust (as a result of burning of accumulated wastes) from the dumpsite. Since Nigeria has no data on the radiological status of these dumpsites any routine monitoring mechanism to check radiation level in waste dumpsites and no effective regulations on the disposal of waste, it is necessary to carry out this research to forestall the possibility of radiation accidents been experienced by other countries.

The city of Amassoma is also noted for its chaotic street patterns with layouts that are hardly drivable by heavy vehicles needed to remove the waste. The roadside and most part of the environ close to residential buildings are gradually becoming unauthorized dumpsites as a result of accelerated rate of flooding, weathering and erosion of the bituminous surface of the soil. Amassoma can be classified as a degraded environment with all manner of waste and refuses littering around the nooks and crannies of the city. This lay credence in evaluating the excess life-time cancer risk (ELCR) from the selected dumpsites and to provide data as part of environmental monitoring research for proper assessment of radiation exposure rate of the populace of the study area.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

The research was conducted in Amassoma, a rural community in Southern Ijaw Local Government Area of Bayelsa state, South-South Nigeria where Niger Delta University is situated. It is one of the communities in Ogboin Clan with the highest population of about 6,970 people. Amasooma is situated on latitude 4.97030 $(458'13.008")N$ and 6.10970$(66'34.992")E$, with an altitude of $79m$. The study area is divided into three wards politically. It is easily accessible by road and water, since it has a major road linking the state capital to its territory and also rivers linking other rural communities. The occupants of the study are Ijaw people and the language spoken is Izon. The major occupations of the Amassoma people are fishing and farming.

2.2. Measurement Techniques

A cross-sectional survey design was adopted for the study and was conducted at all the major dumpsites in Amassoma community. The major dumpsites close to the river, the General Hospital, Niger Delta University (College of Science) and those close to the motorcycle spare parts market in different part of the study area, which are the major contributing factor to waste deposits of the hospital and automobile wastes within the community. Fifteen (15) dumpsites were selected using a single-stage cluster sampling technique. An in-situ approach of background ionizing radiation measurement was adopted to enable samples to maintain their original environmental characteristics. A Digilert 100 nuclear radiation monitor (S.E International, Inc., Summer Town, USA) containing a Geiger-Muller tube capable of detecting α-, β-, γ- and X-rays, pre-set γ-ray measurements, and a geographical positioning system (GPS) was used to measure the precise location of sampling. The assessment was achieved using a factory calibrated Inspector Digilert 100 Nuclear radiation meter (SN:35440, by SE International, Inc., USA). The meter's sensitivity is $3500\ CPM/(mRh^{-1})$ relative to Cs-137, and its maximum alpha and beta efficiencies are 18% and 33%, respectively. It has a halogen-quenched Geiger-Muller detector tube with an effective diameter of 45 mm and a mica window density of 1.5–2.0 mg cm−2 (inspector alert operation manual). The tube of the radiation-monitoring meter was raised to a standard height of 1.0 m above the ground with its window facing the suspected source while the GPS reading was taken at that spot (Avwiri *et al.*, 2013). Measurements of background ionizing radiation were taken at a distance of $5m$ consecutively from one point to another, for fifteen (15) different locations as been shown on the GIS map of the study area, at least ten points were measured for each location. Readings were obtained between 13.00 and 16.00 h because the radiation meter has a maximum response to environmental radiation within these hours according to the NCRP (National Council on Radiation Protection and Measurements 1993).

The obtained data were analyzed using Statistical Package for Social Sciences (SPSS version 26, SPSS Inc. Chicago IL, USA). Descriptive statistics (mean, standard deviation) of various background radiation values was obtained.

3. RESULT AND DISCUSSION

3.1 Results Presentation

Table 1: Measurements obtained from the waste dumpsites at each location.

Location	Average BIR Level (μSvh^{-1})	Equivalent Dose Rate ($mSvy^{-1}$)	Absorbed Dose Rate ($nGyh^{-1}$)	Annual Effective Dose Rate ($mSvy^{-1}$)	Excess Lifetime Cancer Risk (μSvy^{-1})
Okori 1	0.113	0.950	98.31	0.121	0.424
Okori 2	0.092	0.774	80.04	0.098	0.343
Oweidei	0.081	0.681	70.47	0.086	0.301
Okoloba	0.102	0.858	88.74	0.109	0.382
Ikoki	0.137	1.152	119.19	0.146	0.511
Agbedi	0.085	0.715	73.95	0.091	0.319
Ibenikiri	0.099	0.833	86.13	0.106	0.371
Azene	0.081	0.681	70.47	0.086	0.301
Bietebi	0.067	0.563	58.29	0.071	0.249
Nddc Road	0.110	0.925	95.70	0.117	0.410
Chs 1	0.084	0.706	73.08	0.090	0.315
Chs 2	0.090	0.757	78.30	0.096	0.336
PERE-OGBO1	0.102	0.858	88.74	0.109	0.382
PERE-OGBO2	0.114	0.959	99.18	0.122	0.427
WAPERE	0.086	0.723	74.82	0.092	0.322
Minimum	0.067	0.563	58.29	0.071	0.249
Maximum	0.137	1.152	119.19	0.146	0.511
$M \pm SD$	0.96 ± 0.72	0.81 ± 0.15	83.69 ± 5.21	0.10 ± 0.19	0.34 ± 0.07

3.2 Discussion of Results

The results of the measured BIR exposure levels and the calculated hazard indices for the fifteen (15) locations were obtained along the major road to the river then to residential areas are presented in Table 1. Analyses using different known radiation health hazard indices are used in radiation studies to arrive at a more reliable assessment of the health risk to an irradiated person. To assess the radiation hazard associated with the gamma radiation levels in Amassoma community, the following radiation hazard indices were used: Equivalent Dose Rate ($mSvy^{-1}$), Absorbed Dose Rate ($nGyh^{-1}$), Annual Effective Dose Rate ($mSvy^{-1}$), Excess Lifetime Cancer Risk (μSvy^{-1}).

3.2.1. Background Ionizing Radiation (BIR) Exposure Levels

The results of the BIR level measured at the 15 locations that make up the study area shows that the BIR level ranged from $0.067\mu Svh^{-1}$ to $0.137\mu Svh^{-1}$, with a mean value of $0.962 \pm 0.715\mu Svh^{-1}$. the mean values obtained from the fifteen (15) points are above the world average BIR level of $0.013mRh^{-1}$. This indicates that BIR levels in Amassoma are above the recommended limits.

3.2.2. Equivalent Dose Rate (EDR)

To estimate the whole-body equivalent dose rate over a period of one year, we used the national council on radiation protection and measurement recommendation Ononugbo *et al.*, (2011).

$$1\mu Svh^{-1} = 8.76\, mSvy^{-1} \quad (1)$$

The results of the calculated whole body equivalent dose rate are presented in column three (3) of the table. The value of the equivalent dose rate ranged from $0.563\, msvy^{-1}$ to $1.152\, msvy^{-1}$. The results obtained indicate mean value of $0.809 \pm 0.147\, msvy^{-1}$, for the study area. The computed equivalent dose rate of the study area is below the standard permissible limit of 1.0 $msvy^{-1}$ for the public.

3.2.3. Absorbed Dose Rate

The data obtained for the external exposure rate in μRh^{-1} were also converted into absorbed dose rates using the conversion factor:

$$1\mu Rh^{-1} = 8.76nGyh^{-1} = \frac{8.7\times10^{-3}}{\frac{1}{8760y}}\mu Gyy^{-1} = 76.212\mu Gyy^{-1} \quad (2)$$

The results of the gamma radiation absorbed dose rates for the fifteen (15) locations in Amassoma community are presented in column four (4) of the table shown above. The overall mean absorbed dose rate for all 31 points is $83.694 \pm 15.209\, nGyh^{-1}$. The mean value obtained in this community is higher than the world population weighted average gamma dose rate value of $59nGyh^{-1}$.

3.2.4. The Annual Effective Dose Equivalent (AEDE)

The computed absorbed dose rates were used to calculate the annual effective dose equivalent (AEDE) received by residents living in the study area. For the calculation of the AEDE, we used the dose conversion factor of $\frac{0.7Sv}{Gy}$ recommended by UNSCEAR for the conversion coefficient from the absorbed dose in air to the effective dose received by adults and an occupancy factor of 0.2 for outdoor exposure. The annual effective dose equivalent was determined using the equation:

$$AEDE\ (outdoor)(mSvy^{-1}) = Absorbed\ Dose\ (nGyh^{-1}) \times 8760h \times 0.7SvGy^{-1} \times 0.2$$

$$AEDE\ (outdoor)(mSvy^{-1}) = Absorbed\ Dose\ (nGyh^{-1}) \times 1.2264 \times 10^{-3} \quad (3)$$

The overall mean annual equivalent dose rate of $0.103 \pm 0.187mSvy^{-1}$. The worldwide average annual effective dose is $0.41mSv$, of which $0.07mSvy^{-1}$ is from outdoor exposure and $0.34mSvy^{-1}$ is from indoor exposure. The value obtained in the study area is below the world average annual effective dose level for outdoor environments, which is an indication of the fact that the study area is radiological contamination safe.

Excess Lifetime Cancer Risk (ELCR)

The Excess Lifetime Cancer Risk (ELCR) was estimated based on the computed values of AEDE, using the equation:

$$ELCR = AEDE \times Average\ duration\ of\ life(DL) \times Riskfactor\ (RF) \quad (4)$$

Where AEDE is the annual effective dose equivalent, DL, is duration of life (70 years) and RF is the fatal cancer risk factor (Sv^{-1}). For low dose background radiation, which is considered to produce stochastic effects, ICRP 60 uses a fatal cancer risk factor value of 0.05 for public exposure. An overall mean excess lifetime cancer risk (ELCR) of $0.340 \pm 0.066\mu Svy^{-1}$ was obtained the average ELCR value obtained in the current study area is greater than the worlds average value of $0.29 \times 10^{-3} mSvy^{-1}$. This ELCR value indicates that the chance of contracting cancer by residents of the study area who will spend all their lives in the city is likely possible from BIR exposure.

The results obtained show an elevation of the radiation exposure level, equivalent dose rate, absorbed dose rate, and annual effective dose equivalent rate in the study area. However, these values may not constitute any immediate health risk to the residents of Amassoma community. Nonetheless, there may be a likelihood of future, long-term health risks for the populace.

4. CONCLUSION

The evaluation of background Ionization radiation level in fifteen (15) dumpsites in Amassoma in Southern Ijaw Local government area of Bayelsa State, Nigeria has been carried out. The mean average radiation obtained values in all the dumpsites are higher than the normal background standard of 0.013mR/h. The computed equivalent dose rate obtained results are below the dose limit of 1.0mSv/yr for the general public and far lower than dose limit of 20.0mSv/yr for the general public (ICRP, 1999). The results of the absorbed dose rate in the study area is greater than the permissible level of $59nGyh^{-1}$, while the computed Annual Effective dose Equivalent (AEDE) is below the recommended standard value. Finally, the excess lifetime cancer risk (ELCR) computed from the study area is greater than the world average value. These reported values may indicate no immediate radiological health hazards, but may cause long-term health hazard to the occupants, workers and residents of the studied community due to increase with longer period of operation. We therefore recommended the following:

- Waste material must be adequately sorted out and effectively disposed into government approved dumpsites
- There should be a regular monitoring/inspection of radiation levels in the dumpsites by the government.

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