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Investigation of Radiological Hazards Within Uyo Metropolis Central Dumpsite, Akwa Ibom State, Nigeria

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Abstract- The radiological hazard indices due to radiation exposure from the Uyo metropolis central dumpsite were investigated. An in -situ measurements of the exposure level were made using Radex radiation meter model RD 1212. The radiological hazards indices evaluated were, exposure, annual dose rate (ADR), outdoor annual effective dose rate and the excess cancer lifetime risk. The mean exposure obtained for the dumpsite ranged between 0.09 μSv/h -0.19 μSv/h and the corresponding calculated ADR ranged between 0.16 mSv/yr – 0.33 mSv/yr, while the calculated outdoor AEDR is 0.11 mSv/yr -0.23 mSv/yr. The estimated excess lifetime cancer risk due to gamma radiation at the dumpsite is ranged between $0.30\times10^{-3} - 0.82\times10^{-3}$. As a reference to aid observed any significant change in radiation level, the background radiation (control) exposure level was measured and values for exposure, ADR and AEDR (outdoor) were 0.07μSv/h, 0.12 mSv/yr and 0.09 mSv/yr respectively. The results show that the presence of these waste materials have slightly increased the radiation level in the area studied but not large enough for concern as the annual effective dose rate is below the acceptable dose limit of 1mSv/yr for the public, 20mSv/yr occupational limit.

Index Terms- Radiological hazards, exposure, annual dose rate, annual effective dose rate and excess lifetime cancer risk

I. Introduction

The United Nations on Scientific Committee on the Effect of Atomic Radiation Sources and Effect of ionising Radiation identify gamma radiation sources to be rocks, earth crust, soils, plants, water and air (UNSCEAR, 2000). The naturally occurring radioactive material (NORM) found in soils and rocks are mostly radioisotopes of potassium, thorium, uranium, radium and their associated decayed radionuclides and could interact with the environment through human activities. The radionuclides could also be transferred to the soil through rain infiltration process (Taskin, et al, 2009), transferred to man through food ingestion and air inhalation (El Arabi, 2007) and plants absorbed it and consequently act as one of the paths through which radioactivity and radiation get to man (NCRP 1987).

In addition various studies show that these NORM are also present in building materials such as, stones, sand, gravel, cement, concrete, brick, tiles, wood, gypsum, granites etc (Al harbi et al 2011,), in clay soils and river sediments (Ramasammy et al 2009), vegetables, fruits and vegetation contain these radioactive elements (Chibowski, 2000, Akinloye and Olomo, 2005) and in stable food stuffs (Jibiri, 2013). Secondly these materials containing these NORM could form wastes and could constitute source of ionising radiation at the waste dumpsites to the environment and are known to produce radiations that are hazardous to human health (Olubosede, et al, 2012, IAEA 2005).

Interestingly at this dumpsite there are economic activities going on, there are scavengers, farmers and dwelling homes. Therefore every individual working in this environment could suffer from occupational exposure, which is exposure to ionizing radiation at place of work resulting from interaction with radiation emitting sources, in addition to hazards in terms of odour and presence of diseases causing germs.

The knowledge of radiation exposure levels within the dumpsites is necessary to properly guide government, regulators and dumpsite owners on the potential radiation health risks posed by operation of the dumpsite. The aim of this work is to investigate the potential radiological hazards associated with the irradiation of the whole body by these radiations in the study area.

In this study, radiation dose rates, outdoor annual effective dose rate and associated excess lifetime cancer risks (ELCR) from waste materials such as, cements, tiles and timbers, domestic wastes, office wastes etc, in the dumpsite are reported and compared with world acceptable upper limits.

II. Materials and Method

The dumpsite is situated along Udo Street off Wellington Bassey way of Akwa Ibom State, Nigeria. This dumpsite accommodates waste material from smaller waste dumps along the streets of Uyo and is being controlled by Akwa Ibom State ministry of environment. The preliminary studies included visitation of the dumpsite and identification of the controlling agency. The authors explained to the government agent the importance of this investigation and obtained his permission.

Measurement of the exposure level was carried out using Radex (RD 1212) radiation survey meter which measured radiation absorbed dose rate in micro Seviert per hour (μSv/h). The meter was switched on and allowed to absorb radiation for a few seconds and the meter read at the highest stable point. For effective monitoring, the radiation meter was placed at the gonad level of 1m above ground level with the window of the meter directed towards the different piles of waste materials and 10 readings taken in different directions at each pile and the mean recorded. Again background radiation was also measured at 10 m away from the dumpsite and the result taken as control. Measurements of exposure levels in this investigation were taken at 5.0m interval in the afternoon between the hours of 1pm and

4pm for effective response of the meter to environmental radiation exposures according to the method of Inyang et al 2009.

III. CALCULATION OF RADIOLOGICAL HAZARDS INDICES

The exposure (σ) measured in µSv/h is converted to annual absorbed dose rate ADR in mSv/yr according to equation 1.0 (Etuk, et al 2015)

$$ADR(mSv/yr) = \sigma(\mu Sv/h) \times OF \times 24hrs \times 365.25days \times 10^{-3} \quad 1.0$$

OF is the occupancy factor and absorbed dose is obtained in Gy/h from the measured exposure in $\mu Sv/h$ using the relationship

$$D(nGy/h) = \frac{\sigma(\mu Sv/h)}{Q} \times 10^{-3}$$

Q is the quality factor=1.0 for gamma radiation

The annual effective dose rate (AEDR) per year received by workers and the population is obtained from equation 2.0 (UNSCEAR, 2000)

$$AEDR(mSv/yr) = D(nGy/h) \times 8760h \times CF \times OF \quad 2.0$$

CF is the conversion factor of the absorbed dose in air to the effective dose. $CF = 0.7\frac{Sv}{Gy}$, OF is the occupancy factor, the expected period the members of the population would spend within the study area. OF = 0.2 for outdoor as it is expected that human beings would spend 20 % of their time outdoors. Therefore AEDR for outdoor is obtained from equations 4.0 (Gupta and Chauhan 2011)

$$AEDR(m\,{}^{Sv}\!/_{yr})outdoor = D(nGy/h) \times 8760h \times 0.7Sv/Gy \times 0.2 \times 10^{-3} \quad 4.0$$

The excess lifetime cancer risk (ECLR) is calculated from equation 5.0 (Taskin, et al 2009).

$$ECLR = AEDR \times DL \times RF \quad 5.0$$

Where DL is the duration of life (70 years) and RF is the risk factor, that is, the fatal cancer risk per Sievert. For stochastic effects ICRP 60 recommend RF = 0.05 for the public (Taskin, et al 2009).

IV. RESULTS

The mean measured exposure σ, calculated annual absorbed dose rate(ADR), the annual effective dose rate (AEDR) and estimated excess cancer lifetime risk (ECLR) using equations 1.0-5.0 are presented in table 1.

Table 1.0 Measured exposure and calculated radiological hazards indices

S/N	Site location (m)	σ (µSv/h)	ADR (mSv/yr)	AEDR outdoor (mSv/yr)	ECLR outdoor x10^{-3}
1	Control	0.07	0.12	0.09	0.30
2	5.0	0.09	0.16	0.11	0.39
3	10.0	0.11	0.19	0.14	0.47
4	15.0	0.13	0.23	0.16	0.56
5	20.0	0.15	0.26	0.18	0.64
6	25.0	0.16	0.28	0.20	0.69
7	30.0	0.14	0.25	0.17	0.60
8	35.0	0.16	0.28	0.20	0.69
9	40.0	0.18	0.32	0.22	0.77
10	45.0	0.19	0.33	0.23	0.82

The radiological hazard indices obtained from the dumpsite shows the mean exposure ranged between 0.09 µSv/h - 0.19 µSv/h and the corresponding calculated ADR is ranged between 0.16 mSv/yr – 0.33 mSv/yr, while the calculated outdoor AEDR ranged between outdoor are 0.11 mSv/yr - 0.23mSv/yr. The corresponding estimated ECLR is ranged between 0.39 x 10^{-3}-0.82 x10^{-3} with a mean value of 0.63 x 10^{-3}

V. DISCUSSION

The aim of this investigation was to evaluate the contribution of the dumpsite to the exposure level of the environment and compare its value with the world dose limit.

The International Commission on Radiological Protection (ICRP-2007) recommends that any exposure above the natural background radiation should be regulated and kept as low as reasonably achievable (ALARA). This regulation and the consequence of the risk of high radiation exposure necessitated this investigation. It is known that the level of gamma radiation is directly associated with the activity of concentration of these radionuclides in the materials (Taskin, et al 2009).

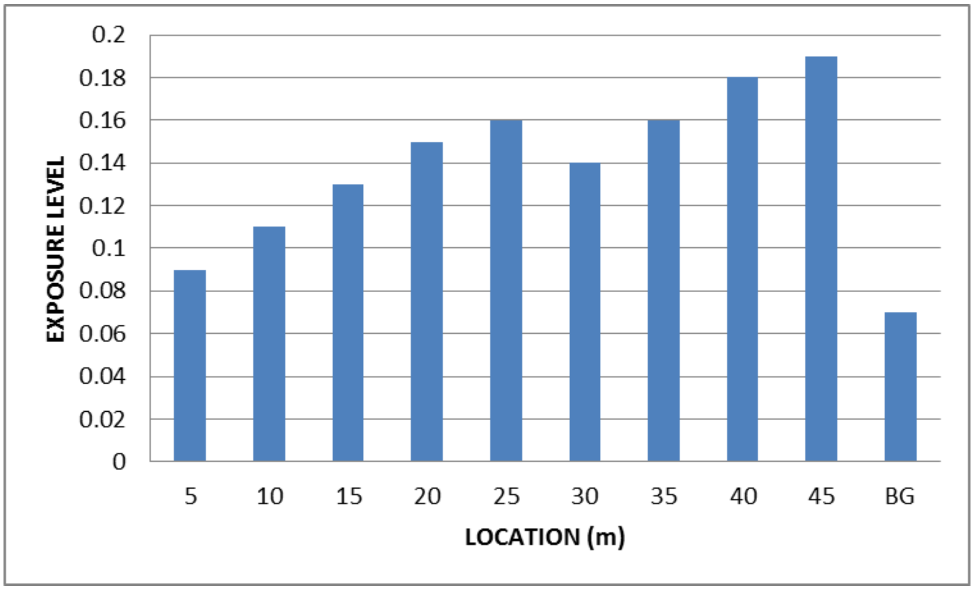

Fig. 1.0 Comparison of the exposure level with location

The results presented in fig. 1.0 shows that the measured mean exposure level of 0.15 µSv/h is higher than the natural background radiation of 0.07 µSv/h. This shows that there is residual radioactivity in the waste materials deposited in the dumpsites which could be from the radionuclides of Radium(Ra), Thorium (Th), Uranium (U) and potassium (K) contain in the material (Michael, et al 2010). These waste materials include refuse materials from plastics, car tyres, paper products, metal scraps, electronics and vegetables waste.

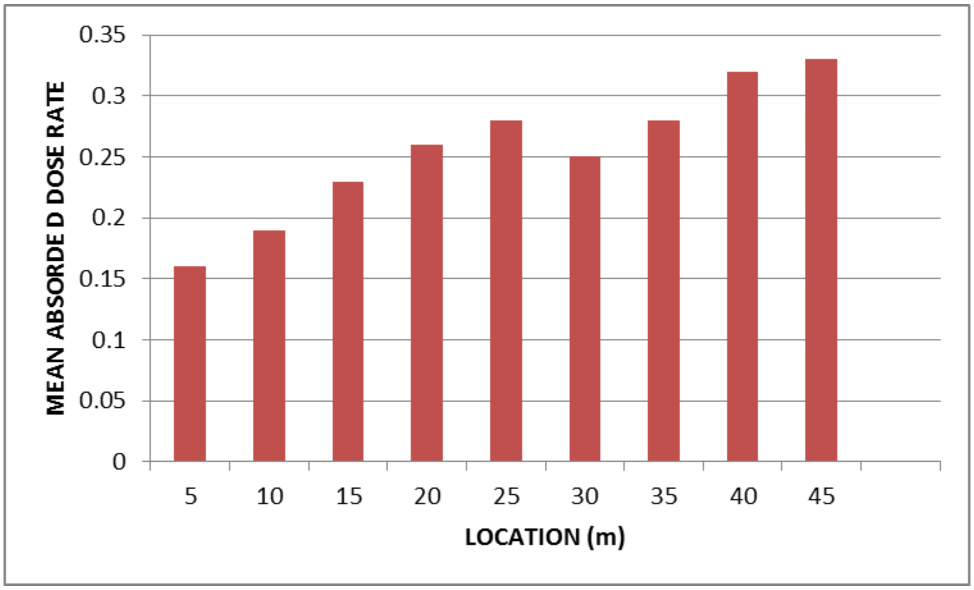

Fig 2.0 Comparison of the ADR (mSv/yr) with the location (m)

The variation in the distribution of the annual absorbed dose rate within the site is shown in fig. 2.0. The mean annual absorbed dose rate of 0.26 mSv/yr was recorded for the dumpsite.

FIG. 3.0 Calculated outdoor annual effective dose rate compared with ICRP dose limit

The calculated annual effective dose rate for outdoor radiation presented in fig.3.0 shows that annual effective dose rate is lower than the ICRP recommended effective dose rate of 1.0 mSv/yr, a limit for the public and the mean lower than the 20 mSv/yr occupational dose limit (NNRA, 2006). The AEDR values (outdoor) is lower than those obtained in similar investigation elsewhere and the worldwide average background radiation of 2.4 mSv/yr (Avwiri and Olatubosun 2014). This could be associated with the difference in the radiation sources and the activity concentrations of the radionuclides in the waste materials investigated. The average total effective dose for outdoor as excess on the background radiation is obtained as 0.18 mSv/yr. This value is lower than the 0.3mSv recommended for building materials as safety limit in the EC guidelines (EC, 1999).

The average estimated excess cancer lifetime risk (ECLR) of 0.33 x $10^{-3}$from the excess gamma radiation from the dumpsite is higher than the world limit of 0.29x10^{-3} (Taskin, et al 2009) while the ECLR from the background radiation is approximately equal to the world average. This should inform the scavengers and workers at the dumpsites to reduce the period of their stay in the site daily and the accumulated years of service eventhough the AEDR is within the permissible limit and the doses are low.

VI. CONCLUSION

The radiation exposure levels in the dumpsite in Uyo metropolis central dumpsite Nigeria have been carried out in order to assess the radiological implications to the workers and the public. The results show that all the radiological hazards indices evaluated were within the acceptable safe limits of 1mSv/yr for the public and the excess effective dose from the dumpsite was below the 0.3mSv/yr. This indicates that the materials in the dumpsites may not pose any significant radiation hazard to the workers and public.

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