



## Preliminary Assessment of Radiometric Survey over a Dumpsite in Eket Urban, South-Eastern Nigeria

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### Abstract

A radiometric survey was conducted at a dumpsite in Eket Urban, south-eastern Nigeria, with the aim of monitoring low-level emission of radioactive contamination. The dumpsite is located behind the defunct Qua Steel Complex in Eket Urban, Akwa Ibom State, Nigeria. The Study area is located between latitude  $04^{\circ}37'07.7''$  and  $04^{\circ}37'00.4''$ N and longitudes  $007^{\circ}56'11.4''$  and  $007^{\circ}56'23.5''$ E, in Benin Formation. The dump contains mixed waste of different materials like kitchen and other household wastes, industrial, agricultural wastes, etc. A portable radiation survey scanner REED R8008 was used to quantify the exposure levels in the dump. Gamma radiation exposure rates in counts per minute (cpm) were obtained from two profiles which were oriented at N  $80^{\circ}$ E and N  $90^{\circ}$  W of the dump at increasing distance of 5m from the reference points.

A plot of exposure rate in counts per minute versus distance reveals that Profile 1 has almost uniform amplitude with a range of 29 to 37 cpm, the highest amplitude recorded at an interval of 90 m. Profile 2 shows higher amplitudes of gamma ray levels ranging from 3.2 to 42.6 cpm, with the relatively higher amplitudes of 40.1 to 42.6 cpm within the dumpsite. A gradual drop towards the adjoining farmland was noticed. The results therefore reveal higher gamma radiation in the dumpsite compared to gamma radiation of 3.2, 3.8, and 3.2 cpm respectively at the three control points. The gamma radiation emission levels from the dump in the range of 20.4 to 42.6 cpm (0.12 to 0.24 Sv/hr) could be accumulated and become hazardous if not properly managed, to forestall the exceeding of 1mSv/year set by the International Commission on Radiological Protection (ICRP) for the environment and general population.

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**Key words:** Radiometric anomalies; dumpsite; Gamma radiation; Benin Formation; Geiger counter

## Introduction

It has been recognized since early studies on X-rays and radioactive minerals that exposure to high levels of radiation can cause clinical damage to the tissues of the human body (IAEA, 1996). In addition, long term epidemiological studies of populations exposed to radiation, especially the survivors of the atomic bombing of Hiroshima and Nagasaki in Japan in 1945, have demonstrated that exposure to radiation also has a potential for the delayed induction of malignancies. It is therefore essential that activities involving radiation exposure, such as the production and use of radiation sources and radioactive materials, and the operation of nuclear installations, including the management of radioactive waste, be subject to certain standards of safety in order to protect those individuals exposed to radiation. Radiation and radioactive substances are natural and permanent features of the environment, and thus the risks associated with radiation exposure can only be restricted, not eliminated entirely.

Radioactive materials are found throughout nature. They are in the soil, water, sediment and vegetation (Bassey et al, 2020, International Atomic Energy Agency (IAEA), 2003). Outside of naturally occurring sources of radiation, there are man – made processes that produce radioactive material that the average person may come in contact with on a regular basis. Gamma rays are the most penetrating radiation from natural and man – made sources (IAEA, 2003). Gamma ray spectrometry is a powerful tool for the monitoring of the radiation environment, which is formed by a flux of elementary particles and energy. The use of gamma ray spectrometry as a tool for mapping radioelement concentrations has found widespread acceptance in diverse fields (IAEA, 2003). This method is widely used for environmental mapping, geological mapping,

soil mapping and for mineral exploration. They may also be used to estimate and assess the terrestrial radiation dose to the human population. Gamma ray spectrometry surveys are also used to assess contamination in areas of former mining, industrial areas, and of refuse dumpsites (IAEA, 2003). Modern instruments can indicate radioactivity over several orders of magnitude. As Geiger counters measure beta particles, they are best suited to ground-based surveys where the distance between the source of the radioactivity and detector is less than a metre (Reynolds, 2011). Hand-held Geiger counters are also used to monitor low-level radioactivity contamination, and certain types of instruments can be used to measure gamma radiation also.

Towns and cities that have experienced rapid growth will have had to contend with the increased levels of waste generation. Urbanization and development bring about higher concentration of commercial, infrastructural, industrial and government activities in such urban areas. Human activities have always generated waste, and refuse dumps can be regarded as primary sources of environmental health hazards to the general public in major cities of the world. Thus, according to Olubosede et al. (2012), the constituents of these wastes, which are usually complex blends of biodegradable and non-biodegradable substances, are compositions of disposed domestic and industrial wastes. Background ionizing radiation (BIR) is constantly emitted by refuse dumps and also Naturally Occurring Radioactive Materials (NORM) in the soil, water, sediment, and vegetation (Bassey et al., 2020, International Atomic Energy Agency, 2003).

## Location and Geology of the Study Area

The sampling location was at a dumpsite behind the defunct Qua Steel Complex in Eket, Akwa Ibom State, Nigeria, with coordinates

between latitudes  $04^{\circ}37'07.7''$  and  $04^{\circ}37'00.4''$ N and longitudes  $007^{\circ}56'11''$  and  $007^{\circ}56'23.5''$ E and elevation of 44 m and 40 m respectively. Geologically, the study area is underlain by the Benin Formation of Oligocene in age with sandy loam soil type. It comprises alternating sequences of gravels and sands of fine to medium/ coarse grain sizes, and Quaternary alluvium (Ugbaja and Edet, 2004). The Benin Formation is Recent in age and it is composed of continental materials such as sand (especially from flood plain), and alluvial deposits. It is good to note that the sand members of the Benin Formation are mature, coarse and poorly to moderately sorted with intercalations of silts and clays (Edet and Okereke, 2002). Vegetation consists of freshwater swamps forest and farmlands. Eket has an estimated population of 242,900 (National Population Commission of Nigeria/National Bureau of Statistics, 2016) and covers an area of approximately 209.7 km<sup>2</sup> and a Population Density of 1, 158/km<sup>2</sup>. The location map is presented in figure 1. The dumpsite is one of the two major dumpsites in Eket. It contains mixed wastes of different sorts ranging from kitchen and other household wastes, industrial, agricultural wastes etc. The odour, unpleasant sight, host to disease-causing organisms, contamination of soil etc., are some of the problems it poses to the environment and its inhabitants. The various types of waste generated by human activities are of varying hazardous effects ranging from relatively innocuous substances to toxic substances including high level (radioactive) waste, which contains harmful substances that pose great hazardous effects to the environment and its inhabitants (Ulakpa et al, 2016).

### Materials and Method

A portable radiation survey scanner REED R8008 was used to quantify the exposure levels in the field. It uses a Geiger-Muller tube to

detect or map  $\alpha$ ,  $\beta$ , and  $\gamma$  radiations, which generate an electrical pulse each time radiation passes through the tube. An in-situ approach was ideal and implemented to ensure samples retained their unique environmental properties. Readings were obtained in the field between the hours of 2 pm and 4 pm. The detector was placed at one meter above the ground for effective detection (Reynolds, 2011). The highest stable point was recorded for each time the meter was switched on. The procedure was repeated every five (5) meters from the reference point and readings in count per minute (cpm) were taken. An average value was determined for each location. Each profile covered a distance of 150 m. Readings for Profile 1 were taken parallel to the waste dump along a footpath about 3 m away from it, while those for Profile 2 were taken from the footpath across the dump and into the adjoining farmland. Data collected are presented in Table 1. Figures 2 and 3 are photographs showing the orientation of profiles 1 and 2. Some locations remote from the dumpsite were selected as control locations; location just before Onna Bridge (3.8 cpm), and 500m from the study site (3.2 cpm), devoid of any buildings or waste from which normal background readings were taken.

### Results

Gamma radiation exposure rates in counts per minutes (cpm) were obtained from two profiles which were oriented at N80°E and N90° W of the dumpsite at increasing distance of 5 m from the reference points. A plot of exposure rate in counts per minute versus distance reveals that Profile 1, as shown in figure 4, has an almost uniform amplitude with a range of 29 to 37 counts per minute, the highest amplitude recorded at an interval of 90 m. Profile 2 was intended to act as a check in level of gamma ray contamination as compared to the surrounding environment. A plot of exposure

rate in counts per minute and distance along Profile 2 shows higher amplitudes of gamma ray activities, ranging from 3.2 to 42.6 cpm, with the higher amplitudes of 40.1 – 42.6 cpm within the dumpsite and a gradual drop towards the adjoining farmland. Higher amplitudes will indicate higher gamma ray activity, while lower amplitudes will indicate lower gamma ray activity. Thus, within the dumpsite, higher

gamma ray activity was recorded as reflected in Figure 5. Gamma ray activity becomes lower as distance from the dumpsite increases towards the adjoining farmland. The results, therefore, reveal higher gamma radiation in the dumpsite as compared to gamma radiation of 3.2, 3.8 and 3.2 cpm respectively at the three control points earlier stated.

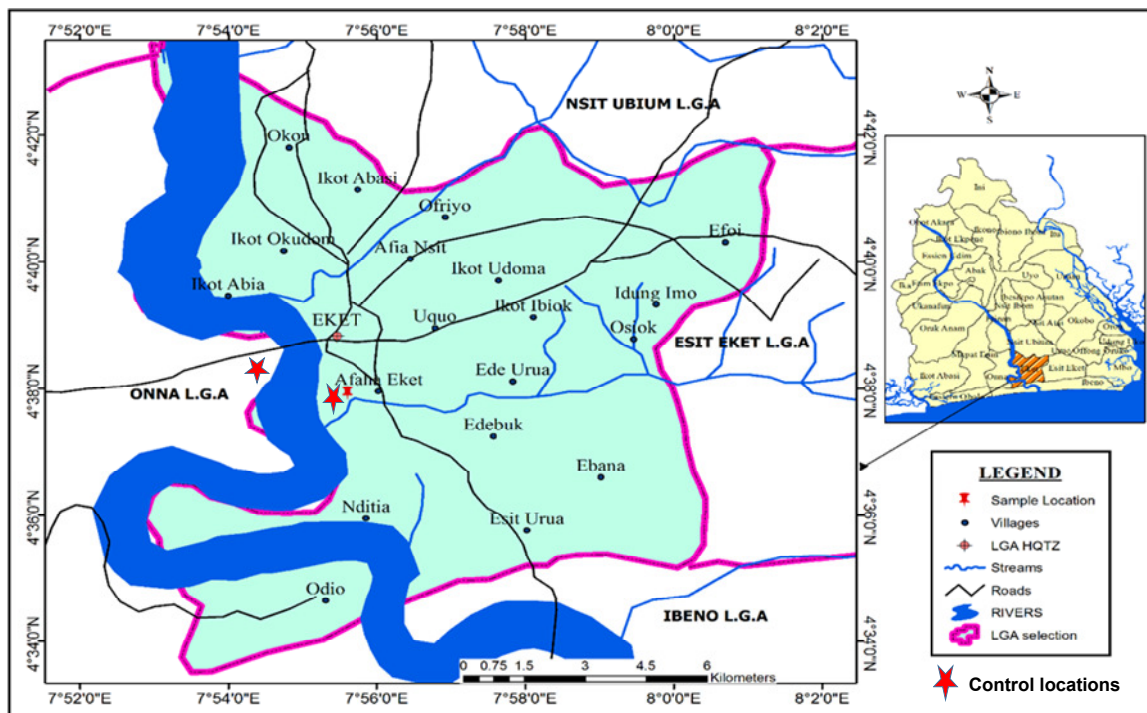


Fig. 1: Map of Eket Local Government Area showing Sample Location

## Discussion

Two environmental questions arise from the presence of radioactive material (Coetzee, 1995). The first is the direct gamma-ray dose obtained as a result of radioactive material in the earth. This is generally low, even in areas of relatively high natural radioactivity. Gamma-rays have a short range in air ( $\pm 600$  m), and attenuation is rapid, so that the direct radiation dose received will be extremely low even close to a source. The second, and the more serious, is the problems related to inhaled radioactive material and radon. Radon is an inert gaseous daughter of uranium, which decays by alpha emission into a series of radioactive isotopes.

The inert radon can escape into air, producing non-inert daughters, which can be absorbed by the human body, where they are absorbed and are able to irradiate tissue, possibly causing cancers. Radon induced lung cancer has been identified as a significant problem in uranium rich areas in other parts of the world. The potential radon hazard in an area is dependent not only on the ground radium concentration, but also on the permeability of the ground, highly permeable areas allowing free flow of radon into buildings. Another concern in new developments is the possibility that radium-rich sand is used for cement and brick making.



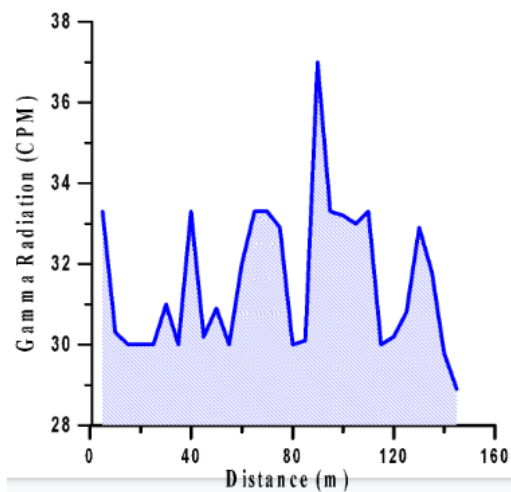
**Fig. 2:** Afaha Eket dumpsite profile 1, N 80° E

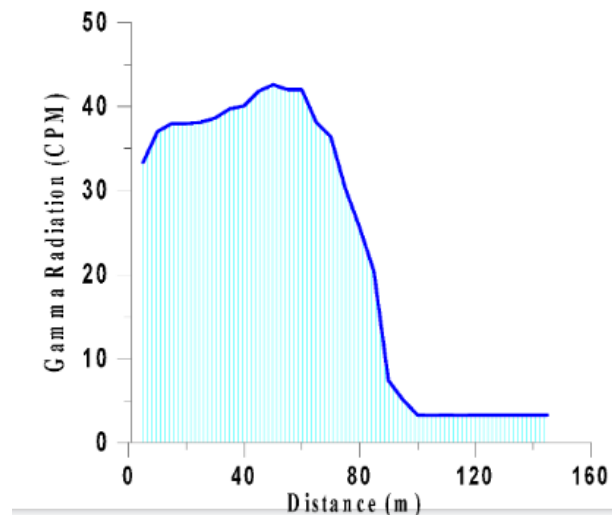


**Fig. 3:** Afaha Eket dumpsite Profile 2, N 90°

**Table 1:** Gamma ray readings for profile 1 and 2

DISTANCE X (m)	Profile1 $\gamma_1$ (cpm)	Profile2 $\gamma_2$ (cpm)
5	33.3	33.3
10	30.3	37.0
15	30.0	38.0
20	30.0	38.0
25	30.0	38.1
30	31.0	38.6
35	30.0	39.7
40	33.3	40.1
45	30.2	41.8
50	30.9	42.6
55	30.0	42.0
60	32.0	42.0
65	33.3	38.1
70	33.3	36.4
75	32.9	30.2
80	30.0	25.7
85	30.1	20.4
90	37.0	7.4
95	33.3	5.1
100	33.2	3.3
105	33.0	3.2
110	33.3	3.3
115	30.0	3.2
120	30.2	3.3
125	30.8	3.3
130	32.9	3.3
135	31.8	3.3
140	29.8	3.3
145	28.9	3.3

**Fig. 4:** Plot of exposure rate in counts per minute and distance for Profile 1



**Fig. 5:** Plot of gamma ray readings in counts per minute versus distance for Profile 2

The value for the dose constraint for public exposure in a planned exposure situation should be below the dose limit for the effective dose of 1 mSv in a year. The dose limit applies to the total dose received by an individual from all sources in planned exposure situations. On the other hand, the value for the dose constraint should be higher than the exemption level established by the regulatory body, e.g., a dose of the order of 10  $\mu$ Sv in a year. Therefore, in practical terms, dose constraints should be selected within the range of 0.1 mSv to < 1mSv in a year (International Atomic Energy Agency (IAEA), 2018). The scope of the Standards is limited to the protection of human beings only; it is considered that standards of protection that are adequate for this purpose will also ensure that no other species is threatened as a population, even if individuals of the species may be harmed. Moreover, the Standards apply only to ionizing radiation, namely gamma and X rays and alpha, beta and other particles that can induce ionization. They do not apply to non-ionizing radiation such as microwave, ultraviolet, visible light and infrared radiation. They do not apply either to the control of non-radiological aspects of health and safety. The Standards recognize that radiation is only one

of many sources of risk in life, and that the risks associated with radiation should not only be weighed against its benefits but also viewed in perspective with other risks (IAEA, 1996). It's normal to find a range of 7-30 cpm in surroundings. Anything below 150 cpm is considered safe, but if the value overshoots this limit, the substance or atmosphere is dangerously radioactive.

It is known that the levels of radiation especially of the gamma type is directly associated with the activity of concentration of radionuclides in materials found at dumpsites (Taskin et al., 2009). On physical inspection, wastes identified in the dump included plastic, shells, debris of buildings, car tires, paper products, metal scraps, human waste, electronics, kitchen wastes and vegetable remains etc. The decomposing process that these items undergo could have been responsible for the high values of gamma ray activity recorded at the dump. Evidences of more hazardous materials like medical wastes and chemical wastes were not identified at the dump. However, the groundwater and soil around the dumpsite may still be contaminated by the radionuclides.

## Conclusion

Practically all terrestrial materials contain measurable quantities of the radioactive elements. In the case of sedimentary deposits, these elements are laid down as components of some mineral in the beds or are precipitated with the sediment subject to the existing physical, colloidal, and chemical conditions. Not only are the atoms of these elements susceptible to subsequent changes of chemical affiliation, but they spontaneously disintegrate according to the laws of radioactivity. The physical characteristics of sedimentary rocks are to be correlated with the lands from which they were derived and with the conditions under which they were laid down. The gamma radiation emission levels from Afaha Eket dumpsite, in the range of 20.4 to 42.6 counts per minute (0.12 to 0.24Sv/hr), could become hazardous if not properly managed by Environmental Impacts Assessment (EIA) experts and other Regulatory Authorities, since they could exceed the permissible limits for the environment and general population.

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