Original Research Article

ASSESSMENT OF BACKGROUND GAMMA RADIATION LEVEL IN SELECTED DUMP SITE OF NIGER DELTA, NIGERIA

Abstract:

Our environment has been ~~expose~~exposed to ionizing radiation from indiscriminate dumping of refuse which is seen as~~,~~ unending and unpreventable phenomenon on earth. Radiation level and exposure risks for some selected dump site in Rivers state have been calculated using radiation exposure rate meter (Radalert-100). The exposure rate measured at Ignatius Ajuru University of Education (IAUE) and its environs ranged from 0.005±0.0001 to 0.016±0.003 mRh^{-1} with mean value of 0.015±0.002 mRh^{-1} while that measured at Igwuruta ranged from 0.009±0.001 to 0.048±0.003 mRh^{-1} with mean value of 0.015±0.002 mRh^{-1}. The exposure rate measured at Aluu ranged from 0.009±0.0001 to 0.015±0.002 mRh^{-1} with mean value of 0.012±0.004 mRh^{-1}. The exposure rates measured in the three dump site are relatively equal but slightly higher than the recommended permissible limit safe value of 0.013 mRh^{-1}. The mean absorbed doses estimated from the exposure rates for Ignatius Ajuru University of Education, Igwuruta and Aluu are 127.72±31.26, 125.91±18.35 and 175.64±41.61 $nGyh^{-1}$ respectively, their mean equivalent doses are 1.16, 1.18 and 1.11 $mSvy^{-1}$ respectively. The annual effective dose equivalent calculated is 0.20±0.03, 0.19±0.03 and 0.19±0.03 $mSvy^{-1}$. The excess lifetime cancer risk estimated ranged from 0.68±0.11, 0.68±0.10 and 0.68±0.10 respectively, they are all above the recommended values $0.29x10^{-3}$ in all the sampling locations. From the radiation level of the dump site, no immediate radiation risk is expected, but there could be a long term effects on those living around the dump side.

Keywords: background ionizing radiation, absorbed dose, annual effective dose equivalent, excess life cancer risk, dumpsites

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Introduction

Since the inception of civilization, waste generation has been an issue for communities. Waste generation is due to activities of human in its environment and utilization of resources. Basically, there are challenges facing the proper management of waste in Rivers State and the country at large, which involve regular increase in population, change in consumption pattern and industrialization. We have complication in solid waste management.

The concept of poor waste management on human health and well-being can't be overemphasized, therefore individuals living around/close to dumpsites are at high risk due to the potential of waste to pollute, food, vegetation, air etc. waste generation are from various sources; offices, agriculture, domestic/residences, institutions, commercial buildings, hospitals, construction etc. all this waste end up in dumpsites. In many states across the country, waste are usually burnt outdoors and ashes are poorly disposed at dump-site, the process destroys the organic components and causes the oxidation of metals. The ashes from the burnt waste is enriched with metal, which results in pollution of the present environment/Soil.(Mustapha et al., 2013).

Open dumpsites could be a source of microbial and toxic chemical pollution of the dumpsites, which poses serious health risks to individual and leading to the destruction of biodiversity in the environment. Basically, Natural radioactivity from the environment is classified into three: Cosmic rays, terrestrial radiation and ingestion. Cosmic rays from our Sun and our galaxy and terrestrial radiation from the Earth crust as well as incorporations of radioisotopes from the biosphere represent whole-body exposures (Ononugbo, 2020). A special role is played by the inhalation of the radioactive noble gas radon which, in particular, represents an exposure for the lungs and the bronchi. In addition to these natural sources further exposures due to technical, scientific and medical installations developed by modern society occur (Ononugbo, 2020). The existence of natural radioactive substances, however demonstrates that radioactivity and the development of life coexisted since the very earliest times on our planet, (Grupen, 2010). Human exposure to ionizing radiation from natural sources is an unending and unpreventable phenomenon on earth (Sadiq and Agba, 2011). Human exposure to natural radiation exceeds that from all man-made sources (Medical, weapons testing and nuclear technologies) put together. The two main contributors to natural radiation exposures are: High-speed cosmic ray particles incidents in the earth's atmosphere and the primordial radionuclides present in the Earth's crust which are present everywhere, including the human body (Ononugbo, 2020). Some exposure to natural radiation sources is modified by human activities. Examples are: Natural radionuclides released into the environment in mineral processing and phosphate fertilizer processing, fossil fuel combustion and quarrying activities, which enhances radiation exposures. Some people are exposed to enhanced levels of radiation at their places of work (Sadiq and Agba, 2011). Only those radionuclides with half-lives comparable to the age of the earth and their decay products, exist in significant quantities in these materials. The estimation of exposure to ionizing radiation is an important goal of regulatory authorities and radiation protection scientists. In public health management of radiation emergencies, one of the essential components of integrated assessment is to quickly and accurately assess and categorize the exposure. Farai and Vincent (2006) measured the outdoor radiation levels in Abeokuta, Nigeria using Thermo luminescent dosimetry and reported that the equivalent dose due to outdoor exposure in the city ranged from 0.19 to 1.64 mSv/yr and a mean of 0.45 mSv/yr and the mean dose of extra-terrestrial radiation was estimated to be 0.18 mSv/yr in the city. A nationwide survey conducted by (Farai and Jibiri, 2000) of terrestrial radiation, using the technique of in-situ gamma spectrometry reported that the mean annual effective dose equivalent is 0.27 mSv/yr. The radiation can cause injuries and clinical symptoms; which may include a chromosomal transformation, cancer induction, free radical formation, bone necrosis and radiation catractogenesis (Norman, 2008). The injuries and clinical symptoms could be caused at both high doses and prolonged low dose exposure. Because of the lethal effects of ionizing radiation, the practice has been to monitor and assess the levels of exposure and keep one's exposure to ionizing radiation as low as reasonably achievable. Previous researchers works h shown that indiscriminate dumping of refuse have great potentials to elevate the level of environmental background ionizing radiation. which have led to the ozone layer depletion and consequently increased cosmic rays reaching the earth surface and affecting the background radiation because most of the refuse ore burnt outdoor.

Materials and Methods

The Radalert 100 used in this study is a digital pocket Geiger counter designed for general purpose monitoring of radioactivity. It detects alpha, beta, gamma and X- radiation, visually shown on a highly accurate digital display with readings in your choice of both CPM (to 110,000 counts per minutes) and mR/hr or switchable to the international standard of µSv/h. The detector is a halogen-quenched Geiger-Mueller tube with mica end window (LND712 or equivalent). Mica window density of 1.5-2.0 mg/cm^2 with side wall of 0.012 inches #446 stainless steel. The energy sensitivity 1000 CPM /mRh^{-1} referenced to Cs-137 and its

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maximum alpha and beta efficiencies are 10 and 15% respectively. An in-situ approach of background ionizing radiation measurement was adopted to enable samples maintain their original environmental characteristics. A well calibrated Radiation monitor, Digilert-200 and Radalert –100 nuclear radiation monitoring meter (S.E. International Incorporation, Summer Town, USA), a Geographical Positioning System (GPS) was used to measure the precise location of sampling, a Geiger-Muller tube capable of detecting alpha, beta, gamma and X-rays was used within the temperature range of -10°C to 50°C. The Geiger-muller tube generates a pulse current each time radiation passes through the tube and causes ionization (Jibiri et al., 2011). Each pulse is electronically detected and registered as a count. The radiation meters were calibrated with a ^{137}Cs source of specific energy and set to measure exposures rate in milli Roentgen per hour (mRhr^{-1}). The meter has an accuracy of ±15%. The tube of the radiation monitoring meter was raised to a standard height of 1.0 m above the ground (Ajayi and Laogun, 2006). With its window facing the suspected source, while the GPS reading was taken at that spot. Measurements were taken within the hours of 11.00 am – 3.00 pm since exposure rate meter has a peak response to environmental radiation within these hours. In order to ensure quality assurance the provisions taken include: Two measuring instruments were deplored to field and standardization of the measuring instruments before use was done, multiplicity of measurement for each sample point (n = 4 for radiation measurements for each sample point). The switch (knob) was turned to return the meter to zero after each measurement. According to (Avwiri et al., 2013), the generated data were converted to absorbed dose rate nGyh^{-1} using the relation for the external exposure rate as follows:

1μR/h = 8.7nGy/h = 8.7×10-^{3} uGy/ (1/8760y)

Radiological Parameters

Equivalent Dose Rate

To estimate the whole body equivalent dose rate over a period of one year, we used the National Council on Radiation Protection and Measurement's recommendation (Ononugbo et al., 2011):

$$1\text{mRh}^{-1} = \frac{0.96 \times 24 \times 365}{100} mSvy^{-1}$$

The results of the calculated whole body equivalent dose rate are presented in Table 1-3.

Absorbed Dose Rate (D)

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The data obtained for the external exposure rate in μRh^{-1} were also converted into absorbed dose rates nGyh^{-1} using the conversion factor (Arogunjo et al., 2004; Avwiri et al., 2013):

$$1\mu Rh^{-1} = 8.7 nGyh^{-1} = \frac{8.7\times10^{-3}}{\left(\frac{1}{8760y}\right)}$$

=76.212 uGyy^{-1}

Annual Effective Dose Equivalent (AEDE)

The computed absorbed dose rates were used to calculate the Annual Effective Dose Equivalent (AEDE) received by the market users. In calculating

AEDE, dose conversion factor of 0.7 Sv/Gy and the occupancy factor for outdoor of 0.25 (6 h out of 24 h) was used. The occupancy factor for outdoor was calculated based upon interviews with traders. People of the study area spend almost 6 h outdoor due to the nature of their routine. The annual effective dose was estimated using the following relation:

$$\text{AEDE (Outdoor) (mSvy}^{-1}) = \text{D (nGyh}^{-1}) \times 8760h \times \frac{0.7Sv}{Gy} \times 0.25 \quad (4)$$

Excess Life Cancer Risk (ELCR)

The annual effective dose calculated was used to estimate the Excess Lifetime Cancer Risk (ELCR) using Equation 5:

$$\text{ELCR} = \text{AEDE} \times \text{Average duration of life} \times \text{Risk Factor Rf} \quad (5)$$

where, AEDE, DL and RF is the annual effective dose equivalent, duration of life (70 years) and risk factor (Sv^{-1}), fatal cancer risk per sievert. For low dose background radiations which are considered to produce stochastic effects, ICRP 60 uses values of 0.05 for the public exposure.

Results ~~And~~and Discussion

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Table 1: Radiation Exposure Rate of IAUE dumpsite

S/N	Sampling Point	Geographical Coordinates	Average Radiation Exposure rate (mR/h)	Equivalent dose rate (μR/h)	Absorbed dose (nGy/hr)	AEDE (mSv/y)	ELCR x 10¯3
1	IAUE 01	No4o48'24 8" E006o56'16.7"	0.010	9.7	84.1	0.13	0.45
2	IAUE 02	N04048'25.4" E006056'16.4"	0.010	10.3	89.9	0.13	0.45
3	IAUE 03	N04048'25.04" E006056'16.3"	0.007	6.7	58.0	0.09	0.31
4	IAUE 04	N04048'26.2" E006056'17.3"	0.012	12.0	104.4	0.16	0.56
5	IAUE 05	N04048'26.2" E006056'17.3"	0.010	10.3	89.9	0.14	0.48
6	IAUE 06	N04048'26.1" E006056'17.4"	0.010	10.3	89.9	0.14	0.48
7	IAUE 07	N04048'26.2" E006056'17.3"	0.010	9.7	84.1	0.13	0.45
8	IAUE 08	N04048'25.4" E006056'18.3"	0.010	10.3	89.9	0.14	0.48
9	IAUE 09	N04048'25.5" E006056'18.3"	0.009	9.3	81.2	0.12	0.44
10	IAUE 10	N04048'25.4" E006056'18.2"	0.010	10.0	87.0	0.13	0.47
11	IAUE 11	N04048'25.8" E006056'17.6"	0.011	12.7	92.8	0.14	0.50
12	IAUE 12	N04048'23.8" E006056'17.6"	0.013	12.7	110.2	0.17	0.59
13	IAUE 13	N04048'23.9" E006056'18.6"	0.010	13.0	87.0	0.13	0.47
14	IAUE 14	N04048'24.0" E006056'18.7"	0.014	13.7	118.9	0.18	0.64
15	IAUE 15	N04048'22.9" E006056'22.3"	0.005	5.0	43.5	0.07	0.23
16	IAUE 16	N04048'22.8"	0.010	10.3	89.9	0.14	0.48

		E006056’2.2”					
17	IAUE 17	N04048’21.5” E006056’24.0”	0.013	12.7	110.8	0.17	0.59
18	IAUE 18	N04048’21.5” E006056’21.4”	0.013	13.0	113.1	0.17	0.61
19	IAUE 19	N04048’21.4” E006056’24.7”	0.013	13.0	113.1	0.17	0.61
20	IAUE 20	N04048’21.0” E006056’24.8”	0.013	13.3	116.0	0.18	0.62
21	IAUE 21	N04048’21.1” E006056’24.7”	0.011	11.0	95.7	0.15	0.51
22	IAUE 22	N04048’22.1” E006056’24.8”	0.011	10.7	92.8	0.14	0.50
23	IAUE 23	N04048’19.7” E006056’26.1”	0.014	13.3	118.9	0.18	0.64
24	IAUE 24	N04048’19.8” E006056’26.2”	0.013	12.7	110.2	0.17	0.59
25	IAUE 25	N04048’20.4” E006056’28.9”	0.015	14.7	127.6	0.20	0.68
26	IAUE 26	N04048’26.0” E006056’27.3”	0.013	13.3	116.0	0.18	0.62
27	IAUE 27	N04048’26.0” E006056’27.3”	0.015	15.0	548.1	0.84	2.94
28	IAUE 28	N04048’25.6” E006056’28.7”	0.016	16.7	553.9	0.85	2.97
29	IAUE 29	N04048’25.6” E006056’28.7”	0.011	11.3	98.6	0.15	0.53
30	IAUE 30	N04048’25.6” E006056’28.8”	0.013	13.3	116.0	0.18	0.62
	Mean value		0.015±0.02	14.7±2.44	127.72±31.26	0.20±0.03	0.68±0.11
	ICRP, 2003		0.013	1.093	84	0.48	0.29

Table 2 Radiation Exposure Rate of **Igwuruta dumpsite**

S/N	Sampling Point	Geographical Coordinates	Average Radiation Exposure rate (mR/h)	Equivalent dose rate (mSv/y)	Absorbed dose (nGy/hr)	AEDE (mSv/y)	ELCR x 10^{-3}
1	IGWRT1	N04^{0}56'11.7" E007^{0}01'53.1"	0.014	14.3	124.7	0.19	0.67
2	IGWRT2	N04^{0}56'11.3" E007^{0}01'52.6"	0.013	12.7	110.2	0.19	0.67
3	IGWRT3	N04^{0}56'11.3.1" E007^{0}01'52.6"	0.013	13.0	113.1	0.17	0.61
4	IGWRT4	N04^{0}56'11.6" E007^{0}01'53.1"	0.012	12.3	107.3	0.16	0.58
5	IGWRT5	N04^{0}56'11.6" E007^{0}1'52.4"	0.010	9.7	86.9	0.85	2.97
6	IGWRT6	N04^{0}56'11.5" E007^{0}01'52.4"	0.011	11.0	95.7	0.15	0.51
7	IGWRT7	N04^{0}56'11.7" E007^{0}01'52.3"	0.011	10.5	91.4	0.14	0.49
8	IGWRT8	N04^{0}56'11.6" E007^{0}1'52.5"	0.010	9.7	84.1	0.13	0.45
9	IGWRT9	N04^{0}56'11.8" E007^{0}01'52.7"	0.010	10.3	89.9	0.14	0.48
10	IGWRT10	N04^{0}56'11.1" E007^{0}01'52.8"	0.011	11.3	98.6	0.15	0.53
11	IGWRT11	N04^{0}56'11.9" E007^{0}01'52.4"	0.009	9.3	81.2	0.12	0.44
12	IGWRT12	N04^{0}56'11.9" E007^{0}01'52.9"	0.009	9.3	81.2	0.12	0.44
13	IGWRT13	N04^{0}56'12.3' E007^{0}01'52.8	0.014	14.3	124.7	0.19	0.67
14	IGWRT14	N04^{0}56'12.3"	0.048	48.3	420.5	0.64	2.26

		E007^{0}01'52.8"					
15	IGWRT15	N04^{4}56'12.5" E007^{0}01'52.5"	0.012	11.7	101.5	0.16	0.54
16	IGWRT16	N04^{0}56'12.5" E007^{0}01'52.6"	0.014	13.7	118.9	0.18	0.64
17	IGWRT17	No4^{0}56'12.6" E007^{0}01'52.7"	0.011	11.0	95.7	0.15	0.51
18	IGWRT18	N04^{0}56'12.4" E007^{0}01'52.4"	0.010	10.3	89.9	0.14	0.48
19	IGWRT19	N04^{0}56'12.4" E007^{0}01'52.2"	0.010	9.7	84.1	0.13	0.45
20	IGWRT20	N04^{0}56'12.5" E007^{0}01'52.2"	0.012	12.3	107.3	0.16	0.58
21	IGWRT21	N04^{0}56'12.6" E007^{0}01'52.2"	0.011	10.7	92.8	0.14	0.50
22	IGWRT22	N04^{0}56'12.6" E007^{0}01'52.3"	0.012	11.7	101.5	0.16	0.54
23	IGWRT23	N04^{0}56'12.7" E007^{0}01'52.4"	0.012	12.0	104.4	0.16	0.56
24	IGWRT24	N04^{0}56'13.0" E007^{0}01'52.9"	0.013	13.3	116.0	0.18	0.62
25	IGWRT25	N04^{0}56'13.0" E007^{0}01'52.9"	0.010	10.0	87.0	0.13	0.47
26	IGWRT26	N04^{0}56'13.1" E007^{0}01'52.9"	0.011	11.0	95.7	0.15	0.51
27	IGWRT27	N04^{0}56'13.0" E007^{0}01'52.0"	0.010	10.3	89.9	0.14	0.48
28	IGWRT28	N04^{0}56'13.0" E007^{0}01'52.0"	0.011	10.7	92.8	0.14	0.50
29	IGWRT29	N04^{0}56'13.0" E007^{0}01'52.0"	0.013	12.7	110.2	0.17	0.59
30	IGWRT30	N04^{0}56'13.9" E007^{0}01'52.6"	0.013	13.0	113.1	0.17	0.61
		Mean value	**0.015±0.002**	**14.5±2.41**	**125.91±18.35**	**0.19±0.03**	**0.68±0.10**
		ICRP (2003)	**0.013**	**1.093**	**84**	**0.48**	**0.29**

Table 3 Radiation Exposure Rate of ALUU dumpsite

S/N	Sampling Point	Geographical Coordinates	Average Radiation level (mR/h)	Average Radiation level (μR/h)	Absorbed dose (nGy/hr)	AEDE (mSv/y)	ELCR x 10^{-3}
1	ALUU 1	N04^{0}56’04.4” E006^{0}57’45.6”	0.014	13.7	118.9	0.18	0.64
2	ALUU 2	N04^{0}56’04.5” E006^{0}57’45.5”	0.010	10.3	89.9	0.18	0.64
3	ALUU 3	N04^{0}56’04.5” E006^{0}57’45.8”	0.011	10.7	92.8	0.14	0.50
4	ALUU 4	N04^{0}56’06.2” E006^{0}57’46.0”	0.011	11.0	95.7	0.15	0.51
5	ALUU 5	N04^{0}56’06.2” E006^{0}57’46.0”	0.010	13.3	89.0	1.38	4.82
6	ALUU 6	N04^{0}56’06.2” E006^{0}57’46.0”	0.011	11.0	95.0	1.47	5.13
7	ALUU 7	N04^{0}56’03.3” E006^{0}57’47.7”	0.010	10.3	89.9	0.14	0.48
8	ALUU 8	N04^{0}56’03.2” E006^{0}57’47.8”	0.010	10.0	87.0	0.13	0.47
9	ALUU 9	N04^{0}56’03.2” E006^{0}57’47.8”	0.010	9.7	84.1	0.13	0.45
10	ALUU 10	N04^{0}56’57.5” E006^{0}57’56.2”	0.007	7.3	71.1	0.26	0.92
11	ALUU 11	N04^{0}56’57.5” E006^{0}57’56.2”	0.009	9.3	81.2	0.12	0.44
12	ALUU 12	N04^{0}56’57.5” E006^{0}57’56.3”	0.010	9.7	84.1	0.13	0.45
13	ALUU 13	N04^{0}56’57.3” E006^{0}57’56.4”	0.014	13.7	118.9	0.18	0.64
14	ALUU 14	N04^{0}56’57.3” E006^{0}57’56.5”	0.011	11.3	98.6	0.15	0.53
15	ALUU 15	N04^{0}56’57.3” E006^{0}57’56.8”	0.013	12.7	110.2	0.17	0.59
16	ALUU 16	N04^{0}56’57.1” E006^{0}57’56.5”	0.010	10.3	89.9	0.14	0.48
17	ALUU 17	N04^{0}56’57.2” E006^{0}57’57..3”	0.010	10.3	82.9	0.98	3.44
18	ALUU 18	N04^{0}56’57.3” E006^{0}57’57.2”	0.009	9.3	81.2	0.12	0.44
19	ALUU 19	N04^{0}56’57.5” E006^{0}57’56.7”	0.012	12.3	88.3	0.16	0.58

20	ALUU 20	N04^{0}56’57.5” E006^{0}57’56.8”	0.010	10.0	87.0	0.13	0.47
21	ALUU 21	N04^{0}56’57.5” E006^{0}57’56.9”	0.010	10.0	87.0	0.13	0.47
22	ALUU 22	N04^{0}56’57.3” E006^{0}57’57.0”	0.010	9.7	84.1	0.13	0.45
23	ALUU 23	N04^{0}56’57.2” E006^{0}57’57.1”	0.010	10.0	87.0	0.13	0.47
24	ALUU 24	N04^{0}56’57.2” E006^{0}57’57.0”	0.010	10.0	87.0	0.13	0.47
25	ALUU 25	N04^{0}56’03.4” E006^{0}57’47.0”	0.014	14.3	102.7	0.19	0.67
26	ALUU 26	N04^{0}56’03.5” E006^{0}57’47.0”	0.015	15.0	130.5	0.20	0.70
27	ALUU 27	N04^{0}56’03.8” E006^{0}57’46.9”	0.014	14.3	124.7	0.19	0.67
28	ALUU 28	N04^{0}56’03.36” E006^{0}57’46.4”	0.014	13.7	118.9	0.18	0.64
29	ALUU 29	N04^{0}56’03.6” E006^{0}57’46.5”	0.014	14.3	124.7	0.19	0.67
30	ALUU 30	N04^{0}56’03.2” E006^{0}57’46.5”	0.013	13.3	116.0	0.18	0.62
Mean value			**0.012±0.004**	**12.2±4.78**	**175.64±41.61**	**0.27±0.06**	**0.94±0.22**
ICRP (2003)			**0.013**	**1.093**	**84**	**0.48**	**0.29**

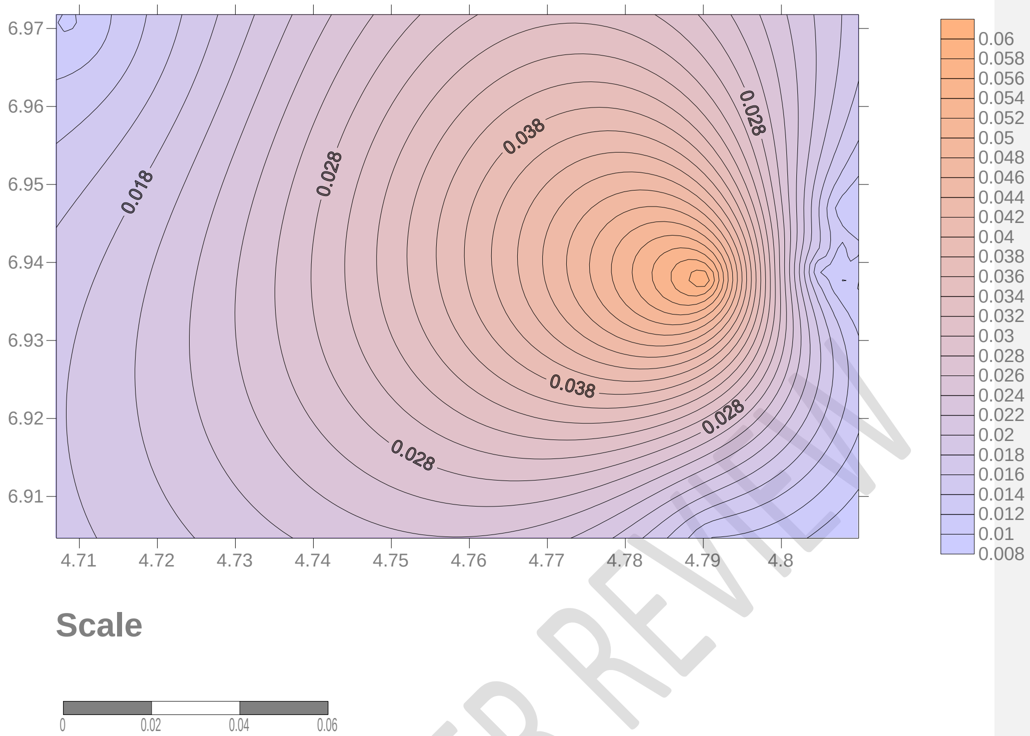

Figure 1: Contour Map of IAUE Dumpsite

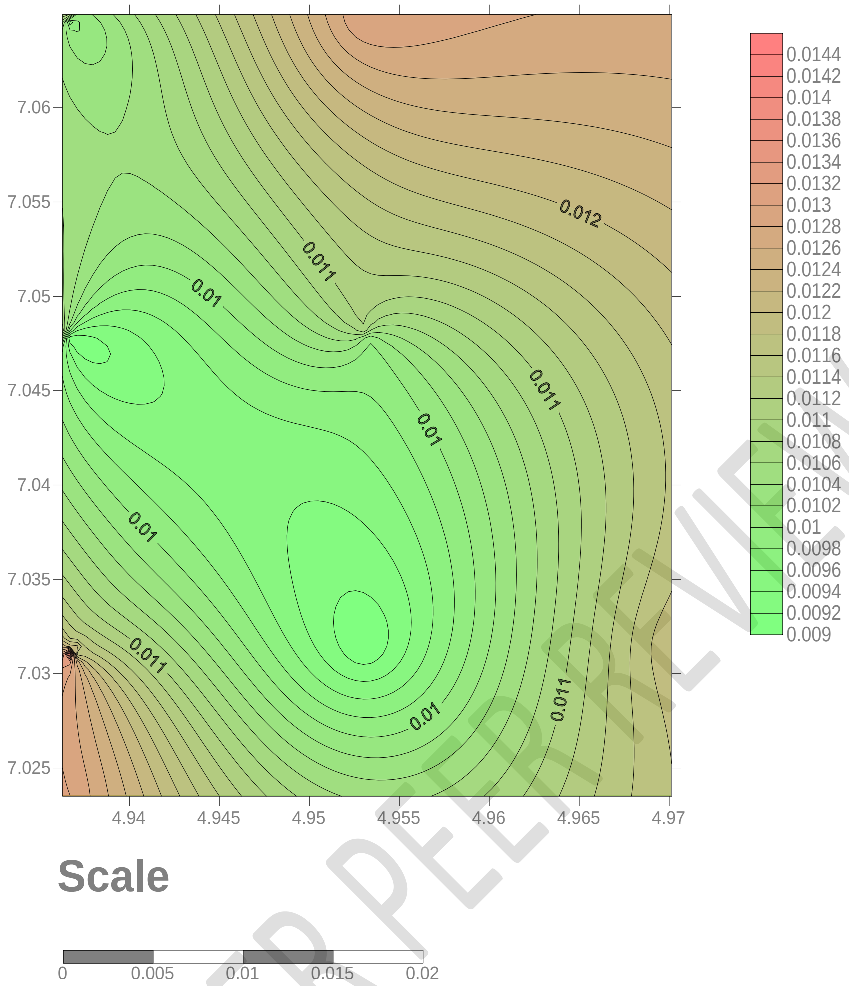

Figure 2: Contour map of Igwuruta Dumpsite

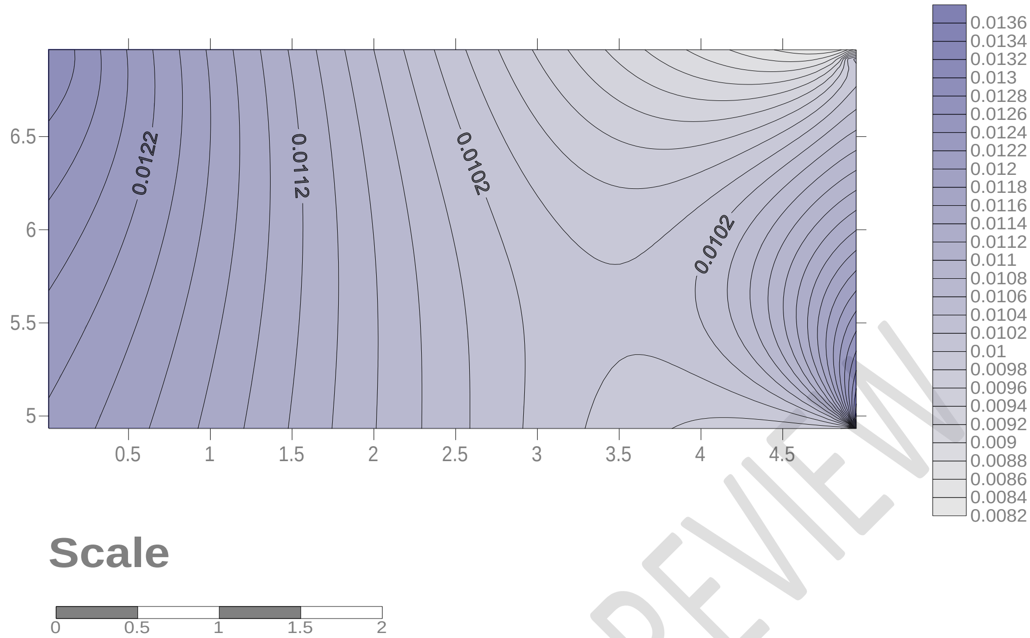

Figure 3: Contour map of Aluu dumpsite

The mean value for absorbed dose rate calculated in IAUE, Iguruta and Aluu dumpsite are 127.72±31.26, 125.91±18.35 and 175.64±41.11 $nGyh^{-1}$ respectively. The values are relatively higher than the recommended safe level of 84.0 $nGyh^{-1}$ (ICRP, 2010). The calculated value for equivalent dose is higher than the recommended value by ICRP. The mean value for calculation of excess lifetime cancer risk is 0.68±0.11, 0.68±0.10 and 0.94±0.22 for IAUE, Iguruta and Aluu respectively, and it exceeded the recommended limit of 0.029×10^{-3}. The mean value for annual effective dose calculated is 0.20±0.03, 0.19±0.03 and 0.27±0.06 for Iguruta and Aluu dumpsite respectively which is lower than the recommended value. The result of this study shows low radiation profile and will not cause any immediate radiation health risk.

Conclusion

The natural background radiations level of the three dumpsite of IAUE, Iguruta and Aluu, has been calculated and the results are in good agreement with those determined in other studies. The radiation level of the study area are relatively low, therefore those living within the dumpsite are within the internationally accepted safe limit for members of the public. The excess lifetime cancer risk and the absorbed dose which was higher than the safe values may not lead to immediate health problem but should be checked for long term exposures. The estimated results should serve as baseline upon which other exposures could be assessed.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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Comment [J7]: Não está em ordem alfabética

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