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

Abstract:

Our environment has been exposed to ionizing radiation from indiscriminate dumping of refuse which is seen as unending and unpreventable challenge on earth. Radiation level and exposure risks in some selected dump site in Rivers state have been calculated using radiation exposure rate meter (Radalert-100). Rate of exposure measured at Ignatius Ajuru University of Education (IAUE) and its environment ranged from 0.005±0.0001 to 0.016±0.003 mRh^{-1} with mean value of 0.015±0.002 mRh^{-1} and that measured at Igwuruta ranged from 0.009±0.001 to 0.048±0.003 mRh^{-1} its mean value is 0.015±0.002 mRh^{-1}. For All, the exposure rate measured ranged from 0.009±0.0001 to 0.015±0.002 mRh^{-1} its mean value is 0.012±0.004 mRh^{-1}. The exposure rates measured in the three dump site are relatively equal and slightly higher than the recommended permissible limit of 0.013 mRh^{-1}. Estimation of the mean absorbed doses 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, its mean absorbed 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 0.29×10^{-3} in all the sampling locations. Following the result 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

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 two: Cosmic rays and terrestrial radiation. 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). 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. 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 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. The aim of this study, is to assess the background gamma radiation level in selected dump site of Niger Delta, Nigeria.

Materials and Methods

The Radalert 100 used in this study is a digital pocket Geiger counter designed general purpose monitoring of background radiation. 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 sidewall of 0.012 inches #446 stainless steel. The energy sensitivity 1000 CPM $/mRh^{-1}$ referenced to Cs-137 and its 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, Radalert –100 nuclear radiation monitoring meter and Geographical Positioning System (GPS) which 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. The knob (switch)was turned to return the meter to zero after each reading.

Radiological Parameters

Absorbed Dose Rate (D)

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)

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

$=76.212\ uGyy^{-1}$

Annual Effective Dose Equivalent (AEDE)

Annual Effective Dose Equivalent (AEDE) were derived from the computed absorbed dose rates received by the people in the environs. 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:

$$\text{AEDE (Outdoor)} (mSvy^{-1}) = D (nGyh^{-1}) \times 8760h \times \frac{0.7Sv}{Gy} \times 0.25 \quad (2)$$

Excess Life Cancer Risk (ELCR)

Excess Lifetime Cancer Risk (ELCR) was derived from the Annual Effective Dose Equivalent of the study.

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

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 Discussion

Table 1: Radiation Exposure Rate of IAUE dumpsite

S/N	Sampling Point	Geographical Coordinates	Average Radiation Exposure rate (mR/h)	Absorbed dose (nGy/hr)	AEDE (mSv/y)	ELCR x 10^{-3}
1	IAUE 01	No4o48’24 8” E006o56’16.7”	0.010	84.1	0.13	0.45
2	IAUE 02	N04048’25.4” E006056’16.4”	0.010	89.9	0.13	0.45
3	IAUE 03	N04048’25.04” E006056’16.3”	0.007	58.0	0.09	0.31
4	IAUE 04	N04048’26.2” E006056’17.3”	0.012	104.4	0.16	0.56
5	IAUE 05	N04048’26.2” E006056’17.3”	0.010	89.9	0.14	0.48
6	IAUE 06	N04048’26.1” E006056’17.4”	0.010	89.9	0.14	0.48
7	IAUE 07	N04048’26.2” E006056’17.3”	0.010	84.1	0.13	0.45
8	IAUE 08	N04048’25.4” E006056’18.3”	0.010	89.9	0.14	0.48
9	IAUE 09	N04048’25.5” E006056’18.3”	0.009	81.2	0.12	0.44
10	IAUE 10	N04048’25.4” E006056’18.2”	0.010	87.0	0.13	0.47
11	IAUE 11	N04048’25.8” E006056’17.6”	0.011	92.8	0.14	0.50
12	IAUE 12	N04048’23.8”	0.013	110.2	0.17	0.59

		E006056’17.6”				
13	IAUE 13	N04048’23.9” E006056’18.6”	0.010	87.0	0.13	
14	IAUE 14	N04048’24.0” E006056’18.7”	0.014	118.9	0.18	0.64
15	IAUE 15	N04048’22.9” E006056’22.3”	0.005	43.5	0.07	0.23
16	IAUE 16	N04048’22.8” E006056’2.2”	0.010	89.9	0.14	0.48
17	IAUE 17	N04048’21.5” E006056’24.0”	0.013	110.8	0.17	0.59
18	IAUE 18	N04048’21.5” E006056’21.4”	0.013	113.1	0.17	0.61
19	IAUE 19	N04048’21.4” E006056’24.7”	0.013	113.1	0.17	0.61
20	IAUE 20	N04048’21.0” E006056’24.8”	0.013	116.0	0.18	0.62
21	IAUE 21	N04048’21.1” E006056’24.7”	0.011	95.7	0.15	0.51
22	IAUE 22	N04048’22.1” E006056’24.8”	0.011	92.8	0.14	0.50
23	IAUE 23	N04048’19.7” E006056’26.1”	0.014	118.9	0.18	0.64
24	IAUE 24	N04048’19.8” E006056’26.2”	0.013	110.2	0.17	0.59
25	IAUE 25	N04048’20.4” E006056’28.9”	0.015	127.6	0.20	0.68
26	IAUE 26	N04048’26.0” E006056’27.3”	0.013	116.0	0.18	0.62
27	IAUE 27	N04048’26.0” E006056’27.3”	0.015	548.1	0.84	2.94
28	IAUE 28	N04048’25.6” E006056’28.7”	0.016	553.9	0.85	2.97
29	IAUE 29	N04048’25.6” E006056’28.7”	0.011	98.6	0.15	0.53
30	IAUE 30	N04048’25.6” E006056’28.8”	0.013	116.0	0.18	0.62
	Mean value		0.015±0.02	127.72±31.26	0.20±0.03	0.68±0.11
	ICRP, 2003		0.013	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)**	**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	124.7	0.19	0.67
2	IGWRT2	N04^{0}56’11.3” E007^{0}01’52.6”	0.013	110.2	0.19	0.67
3	IGWRT3	N04^{0}56’11.3.1” E007^{0}01’52.6”	0.013	113.1	0.17	0.61
4	IGWRT4	N04^{0}56’11.6” E007^{0}01’53.1”	0.012	107.3	0.16	0.58
5	IGWRT5	N04^{0}56’11.6” E007^{0}1’52.4”	0.010	86.9	0.85	2.97
6	IGWRT6	N04^{0}56’11.5” E007^{0}01’52.4”	0.011	95.7	0.15	0.51
7	IGWRT7	N04^{0}56’11.7” E007^{0}01’52.3”	0.011	91.4	0.14	0.49
8	IGWRT8	N04^{0}56’11.6” E007^{0}1’52.5”	0.010	84.1	0.13	0.45
9	IGWRT9	N04^{0}56’11.8” E007^{0}01’52.7”	0.010	89.9	0.14	0.48
10	IGWRT10	N04^{0}56’11.1” E007^{0}01’52.8”	0.011	98.6	0.15	0.53
11	IGWRT11	N04^{0}56’11.9”	0.009	81.2	0.12	0.44

		E007^{0}01’52.4”				
12	IGWRT12	N04^{0}56’11.9” E007^{0}01’52.9”	0.009	81.2	0.12	0.44
13	IGWRT13	N04^{0}56’12.3’ E007^{0}01’52.8	0.014	124.7	0.19	0.67
14	IGWRT14	N04^{0}56’12.3” E007^{0}01’52.8”	0.048	420.5	0.64	2.26
15	IGWRT15	N04^{4}56’12.5” E007^{0}01’52.5”	0.012	101.5	0.16	0.54
16	IGWRT16	N04^{0}56’12.5” E007^{0}01’52.6”	0.014	118.9	0.18	0.64
17	IGWRT17	No4^{0}56’12.6” E007^{0}01’52.7”	0.011	95.7	0.15	0.51
18	IGWRT18	N04^{0}56’12.4” E007^{0}01’52.4”	0.010	89.9	0.14	0.48
19	IGWRT19	N04^{0}56’12.4” E007^{0}01’52.2”	0.010	84.1	0.13	0.45
20	IGWRT20	N04^{0}56’12.5” E007^{0}01’52.2”	0.012	107.3	0.16	0.58
21	IGWRT21	N04^{0}56’12.6” E007^{0}01’52.2”	0.011	92.8	0.14	0.50
22	IGWRT22	N04^{0}56’12.6” E007^{0}01’52.3”	0.012	101.5	0.16	0.54
23	IGWRT23	N04^{0}56’12.7” E007^{0}01’52.4”	0.012	104.4	0.16	0.56
24	IGWRT24	N04^{0}56’13.0” E007^{0}01’52.9”	0.013	116.0	0.18	0.62
25	IGWRT25	N04^{0}56’13.0” E007^{0}01’52.9”	0.010	87.0	0.13	0.47
26	IGWRT26	N04^{0}56’13.1” E007^{0}01’52.9”	0.011	95.7	0.15	0.51
27	IGWRT27	N04^{0}56’13.0” E007^{0}01’52.0”	0.010	89.9	0.14	0.48
28	IGWRT28	N04^{0}56’13.0” E007^{0}01’52.0”	0.011	92.8	0.14	0.50
29	IGWRT29	N04^{0}56’13.0” E007^{0}01’52.0”	0.013	110.2	0.17	0.59
30	IGWRT30	N04^{0}56’13.9” E007^{0}01’52.6”	0.013	113.1	0.17	0.61
		Mean value	**0.015±0.002**	**125.91±18.35**	**0.19±0.03**	**0.68±0.10**
		ICRP (2003)	**0.013**	**84**	**0.48**	**0.29**

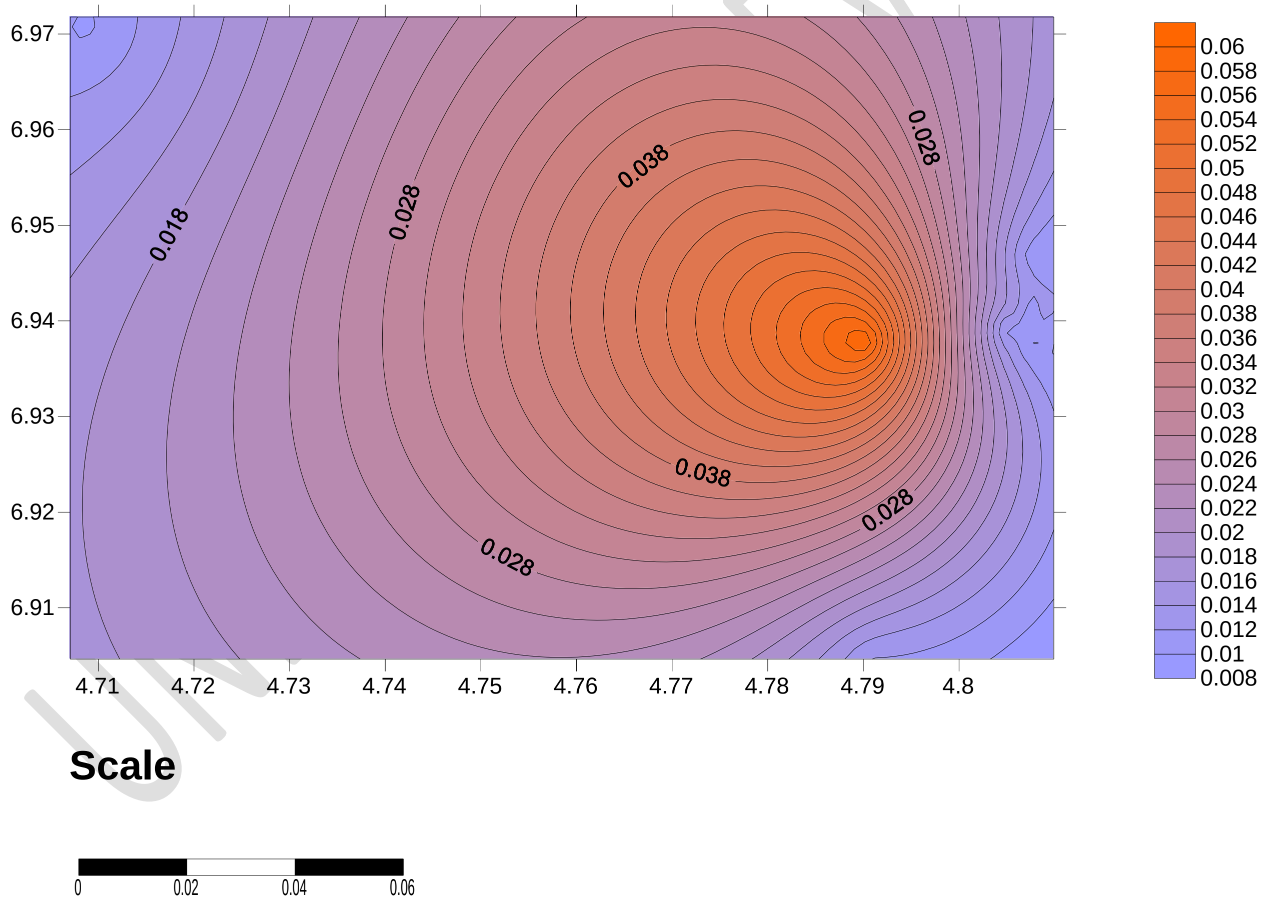
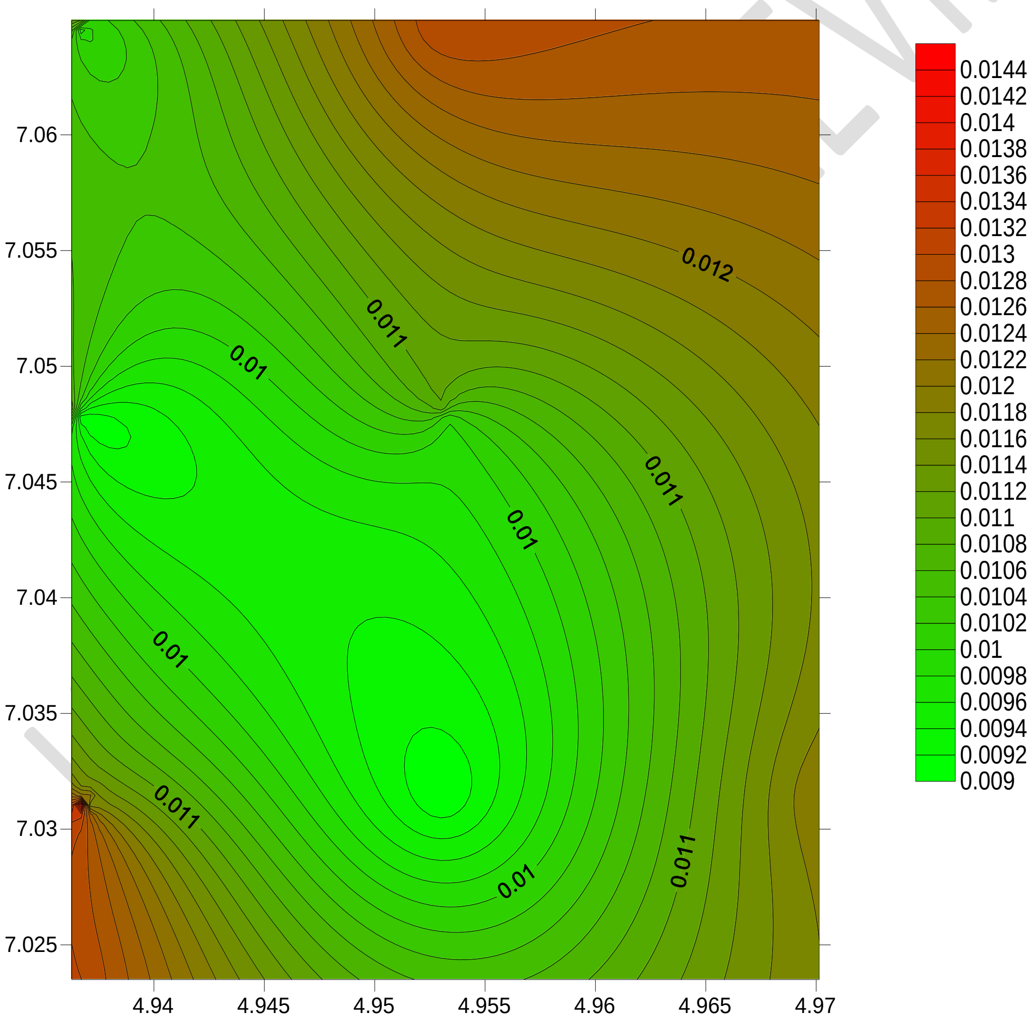


Figure 1: Contour Map of IAUE Dumpsite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Scale

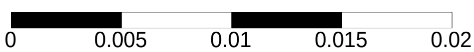
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Figure 2: Contour map of Igwuruta Dumpsite

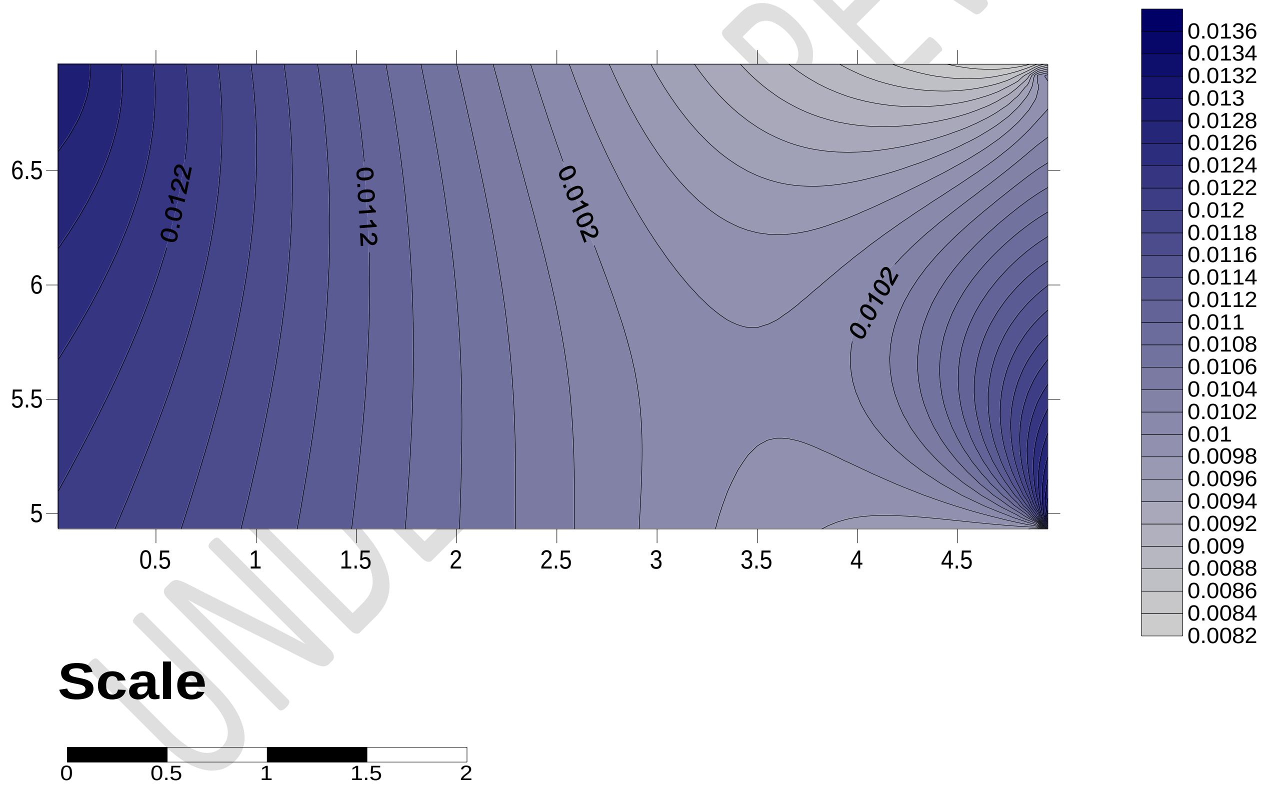

Figure 3: Contour map of Aluu dumpsite

Background radiation level of selected dumpsite in Niger Delta, Nigeria have been assessed using special meters design for its purpose. Table 1 and 2 shows the Radiation Exposure Rate of IAUE, Iguruta and Aluu dumpsite respectively, 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 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}. Annual Effective Dose was also calculated and its mean value are 0.20±0.03, 0.19±0.03 and 0.27±0.06 for IAUE, Iguruta and Aluu dumpsite respectively which is lower than the recommended value. Radiation levels of selected dumpsite of Niger Delta, Nigeria in this study is slightly higher than the result of Ugbede, (2018) carried out in Ebonyi State Nigeria and the save level of 0.013 mR/h. contour map of the study areas are presented in table 1 to 3 showing the radiation distribution of different level of radiation, the spacing of the contour lines, indicates the relative slope of the surface.

Conclusion

The natural background radiations level of the three selected dumpsite of IAUE, Iguruta and Aluu, has been assessed and the results are in agreement with those determined in other studies. The radiation level of the study area are relatively higher than other study which could be due to non-proper management of waste from indiscriminate dumping of different class of waste. There should be periodic check on the level of radiation around the study area, though there may be no immediate health challenges. The excess lifetime cancer risk and the absorbed dose is also higher than the safe values which may not also 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.

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