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Assessment of Environmental Radioactivity in the Federal University Otuoke, Bayelsa State, Nigeria

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Abstract: *Assessment of environmental radioactivity has been performed using radiation meters, Radalert-100 Digilert-200, and a geographical positioning system (GPS) within the Federal University Otuoke, Bayelsa State Nigeria. Three to four readings were taken at each point and the mean value recorded as exposure level with standard deviation. The average exposure rate ranged from 9.0 to 29.0μRh^{-1}. The exposure dose rate (D), annual effective dose equivalent (AEDE), excess lifetime cancer risk (ELCR) were computed and they ranged from 87.0 to 252.3nGyh^{-1}, 0.107 to 0.309mSvy^{-1}, 0.005 to 0.15x10^{-3} respectively. The results at some points showed elevation above the maximum permissible limits as recommended by the International Council on Radiological Protection for the public and nonnuclear environment. This study provides baseline data for future environmental studies. As much as the excess lifetime cancer risk is not excessive, regular monitoring is recommended since the university is in close proximity with hydrocarbon exploration and exploitation zones. This is in a view to checking sudden elevation, bearing in mind that the short and long term health side effects of elevated background ionizing radiation (BIR) resulting from Technologically Enhanced Naturally Occurring Radioactive Materials (TENORMs) are undesirable.*

Keywords: *Assessment; Dose; Environment; Exposure; Radioactivity.*

1. INTRODUCTION

In recent time environmental physicists and medical physicists are showing great concern over the frequent illnesses that may associate with ionizing radiations. The earth and its atmosphere consist of radioactive elements that may be found naturally in the earth's environment. These elements are referred to as Naturally Occurring Radioactive Materials (NORMs)**.** Examples of these radioactive elements are the ^{238}U, ^{235}U, ^{232}Th series and their respective decay daughters, as well as ^{40}K. NORMs exist in soil, water, plants, animals, human, coal, lignite, petroleum, phosphate ores, geothermal wastes, waste waters *et cetera*, in small but varying amounts almost everywhere [1]. These elements and compounds constitute environmental pollution.

The environment is defined as the surroundings or conditions in which a person, animal, or plant lives or operates [2]. Environment can also be defined as all the biotic and abiotic factors that act on organism, population or ecological community and influence their survival and development (freedictionary.com). [3] stated that there is need to maintain the environment in recognition of the implication of oil and gas exploration and exploitation. In this regard, the millennium Development Goal 7 sought to explain the importance of environmental sustainability. Environmental pollution is therefore the infiltration into the environment, biological or chemical substances that are in identifiable excess and are known to be harmful to other desirable living and non living things within the environment [4]. [5], from soil management perception defined environmental pollution as the unfavourable alteration of our surroundings, through direct or indirect effects of changes in energy pattern, radiation levels, chemical and physical concentration and abundance of organisms. Basically environmental pollution occurs on land, in air and in water.

This study primarily focused on ionizing radiation existing naturally or that which may emanate through the activities of man on planet earth. Radiation pollution is any form of ionizing or non ionizing radiation that results from human activities [6]. The most well-known radiation results from the detonation of nuclear devices and the controlled release of energy by nuclear-power generating plants and of course the natural earth crust. Public concern over the release of radiation into the environment greatly increased, for example, through the disclosure of possible harmful effects to the public from nuclear weapons testing, the 1979 accident at the Three Mile Island nuclear power generating plant near Harrisburg, and the catastrophic 1986 explosion at Chernobyl, a Soviet nuclear power plant. In the late 1980s, revelations of major pollution problems at U.S nuclear weapons reactors raised apprehensions even higher [7], and the 2011 Fukushima nuclear power plant melt down that cause high radioactive releases into the environment.

The environmental effects of exposure to high level ionizing radiation have been extensively documented through post war studies on individuals who were exposed to nuclear radiation in Japan. Some forms of cancer showed up immediately, but latent maladies of radiation poisoning have been recorded from 10 to 30 years after exposure. A major concern about this type of exposure is the potential for genetic damage. In this regard radiation emanating naturally or through hydrocarbon is also considered to be a concern irrespective of the level. There is no record incident of radioactive material release in the Federal University Otuoke.

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Radiation emanating from hydrocarbon is also considered to be a concern irrespective of the level. Crude oil spill is sudden release of oil onto the soil or into a body of water and usually present a hazard to the environment. Oil spillage could occur as a result of equipment failure or through act of pipe line vandalization. According to [8], oil spills occur due to a number of causes, including: corrosion of pipelines and tankers (accounting for 50% of all spills), sabotage (28%), and oil production operations (21%), with 1% of the spills being accounted for, by inadequate or non-functional production equipment. Oil spills have posed a major threat to the environment of the oil producing areas, which if not effectively checked can lead to the total destruction of ecosystems. According to [9], an estimated 9 million to 13 million (1.5 million tons) of oil has been spilled into the Niger Delta ecosystem over the past 50 years. Frequent oil spillage could have negative environmental consequences. However, Federal University Otuoke has no record of incident of oil spill though in proximity with oil and gas activities.

There are various criteria for the classification of the detrimental radiation effects on biological system. There are two major classifications of radiation effects on biological systems namely deterministic and stochastic effects. This depends on presence or absence of a threshold radiation dose to produce health effect.

1.1. Study Area

The study area is the Federal University Otuoke Bayelsa State and lies between latitude 4^0 47.43’ and 4^0 48.14’ and longitude 6^0 18.96’ and 6^0 19.64’. It is located within the Niger Delta region of Nigeria and the geology of the Niger Delta area has been widely reported [10]; [11]. The study area is classified into six zones for the purpose of this study. Zone A and B make up the main campus. Zone C the hostel complex, Zone D the administrative area, Zone E is the skill acquisition area and Zone F is the final year female hostel area.

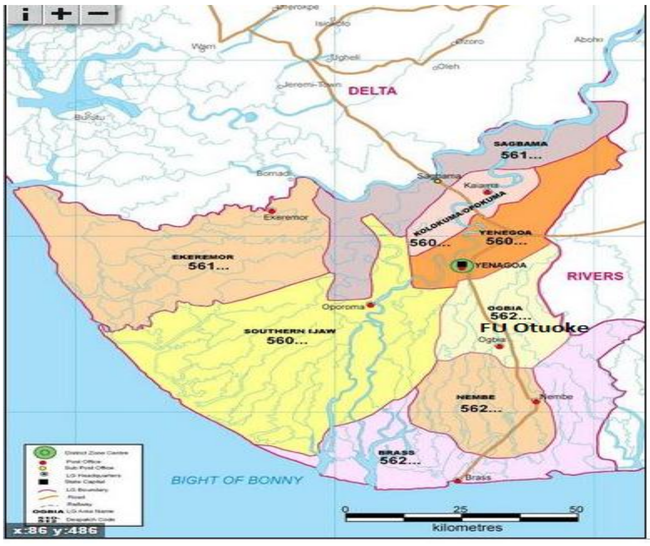

Fig1. *Map of the study area*

2. Experimental Method

The measurement of the background ionizing radiation was conducted *in situ*. This was to make sure that the survey was done under natural environmental conditions and characteristics. Well calibrated Digilert-200 and Radalert-100 nuclear radiation monitoring meters were used in addition to the geographical positioning system. The radiation meters utilized the principle of Geiger Muller tube, while a geographical positioning system (GPS) was used to identify the exact location of each reading obtained. Readings were taken between 1300 and 1600 hours. Within these hours as recommended by [12], radiation meters have the maximum response to environmental radiation. Measurements were taken three to four times at each point and the average of exposure level was later determined. The procedure was that the meters were held 1 m above the ground level in accordance with that reported by [13]. The unit of measurement was in milli Roentgen per hour (mRh^{-1}) but the average exposure was later converted to micro Roentgen per hour (μRh^{-1}). Exposed dose rate was calculated from the average exposure rate. The annual effective dose equivalent (AEDE) was also calculated from the dose rate and finally the excess lifetime cancer risk was computed from the AEDE.

3. Results and Discussions

3.1. Results

Table1. *Main Campus Zone A*

S/N	Geological Location	Exposure Rate (mRh^{-1})	Exposure Rate (mRh^{-1})	Average Exposure Rate (μRh^{-1})	Dose ($nGyh^{-1}$)	AEDE ($mSvy^{-1}$)	ELCR $x10^{-3}$
1	4^0 47.537'N 6^0 19.274'E	0.014±0.005	0.020±0.007	17.0±0.006	147.9	0.181	0.009
2	4^0 47.561'N 6^0 19.299'E	0.020±0.002	0.021±0.004	21.0±0.003	182.7	0.224	0.011
3	4^0 47.515'N 6^0 19.249'E	0.009±0.006	0.019±0.008	14.00±0.007	121.8	0.149	0.007
4	4^0 47.460'N 6^0 19.194'E	0.020±0.009	0.014±0.005	17.0±0.007	149.9	0.181	0.009
5	4^0 47.470'N 60 19.281'E	0.024±0.007	0.033±0.005	29.0±0.006	252.3	0.309	0.015
6	4^0 47.510'N 6^0 19.321'E	0.010±0.008	0.011±009	11.0±0.008	95.7	0.117	0.006
7	4^0 47.428'N 6^0 19.294'E	0.008±0.008	0.010±0.005	9.0±0.006	78.3	0.96	0.005
	ICRP STD	0.013	0.013	13	84	1	0.29

Table2. *Main Campus Zone B*

S/N	Geological Location	Exposure Rate (mRh^{-1})	Exposure Rate (mRh^{-1})	Average Exposure Rate (μRh^{-1})	Dose ($nGyh^{-1}$)	AEDE ($mSvy^{-1}$)	ELCR $x10^{-3}$
1	4^0 47.506'N 6^0 19.184'E	0.012±0.006	0.010±0.007	11.0±0.006	95.7	0.117	0.006
2	4^0 47.501'N 6^0 19.146'E	0.017±0.009	0.012±0.007	15.0±0.008	130.5	0.160	0.008
3	4^0 47.497'N 6^0 19.137'E	0.020±0.004	0.018±0.007	19.0±0.005	165.3	0.203	0.010
4	4^0 47.558'N 6^0 19.177'E	0.016±0.003	0.018±0.006	17.0±0.004	147.9	0.181	0.009
5	4^0 47.595'N 6^0 19.167'E	0.020±0.001	0.020±0.004	20.0±0.002	174.0	0.213	0.011
6	4^0 47.603'N 6^0 19.210'E	0.011±0.006	0.008±0.004	10.0±0.005	87.0	0.107	0.005
7	4^0 47.658'N 6^0 19.224'E	0.011±0.006	0.008±0.007	10.0±0.006	87.0	0.107	0.005
	ICRP STD	0.013	0.013	13	84	1	0.29

Table3. *Hostel Zone C*

S/N	Geological Location	Exposure Rate (mRh^{-1})	Exposure Rate (mRh^{-1})	Average Exposure Rate (μRh^{-1})	Dose ($nGyh^{-1}$)	AEDE ($mSvy^{-1}$)	ELCR $x10^{-3}$
1	4^0 47.561'N 6^0 19.390'E	0.016±0.006	0.013±0.006	15.0±0.006	130.5	0.160	0.008
2	4^0 47.572'N 6^0 19.406'E	0.014±0.007	0.025±0.008	20.0±0.007	174.0	0.213	0.011
3	4^0 47.527'N 6^0 19.400'E	0.006±0.006	0.002±0.007	4.0±0.006	34.8	0.043	0.002
4	4^0 47.577'N 6^0 19.360'E	0.017±0.008	0.014±0.006	16.0±0.007	139.2	0.171	0.009
5	4^0 47.621'N 6^0 19.344'E	0.020±0.006	0.019±0.009	20.0±0.007	174.o	0.213	0.011
6	4^0 47.614'N 6^0 19.420'E	0.015±0.006	0.014±0.004	15.0±0.005	130.5	0.160	0.008
7	4^0 47.640'N 6^0 19.445'E	0.020±0.003	0.014±0.005	17.0±0.004	147.9	0.181	0.009
	ICRP STD	0.013	0.013	13	84	1	0.29

Table4. *Admin Zone D*

S/N	Geological Location	Exposure Rate (mRh^{-1})	Exposure Rate (mRh^{-1})	Average Exposure Rate (μRh^{-1})	Dose ($nGyh^{-1}$)	AEDE ($mSvy^{-1}$)	ELCR $x10^{-3}$
1	4^0 47.863N 6^0 19.297E	0.016±0.008	0.007±0.007	12.0±0.007	104.4	0.128	0.006
2	4^0 47.888N 6^0 19.312E	0.008±0.006	0.011±0.009	10±0.007	87.0	0.107	0.005
3	4^0 47.844N 6^0 19.309E	0.009±0.007	0.019±0.005	14±0.006	121.8	0.149	0.007
4	4^0 47.829N 6^0 19.273E	0.010±0.001	0.014±0.008	12±0.004	104.4	0.128	0.006
5	4^0 47.904N 6^0 19.279E	0.019±0.003	0.013±0.009	16±0.006	139.2	0.171	0.009
6	4^0 47.844N 6^0 19.248E	0.033±0.008	0.014±0.009	24±0.008	208.8	0.256	0.013
7	4^0 47.890N 6^0 19.245E	0.024±0.005	0.028±0.007	26±0.006	226.2	0.277	0.014
	ICRP STD	0.013	0.013	13	84	1	0.29

Table5. *Acquisition Zone E*

S/N	Geological Location	Exposure Rate (mRh^{-1})	Exposure Rate (mRh^{-1})	Average Exposure Rate (μRh^{-1})	Dose ($nGyh^{-1}$)	AEDE ($mSvy^{-1}$)	ELCR $x10^{-3}$
1	4^0 47.976N 6^0 19.639E	0.020±0.007	0.018±0.008	19.0±0.007	169.3	0.203	0.010
2	4^0 47.921N 6^0 19.616E	0.010±0.006	0.015.007	13.0±0.006	113.1	0.139	0.007
3	4^0 48.005N 6^0 19.531E	0.020±0.005	0.025±0.006	23.0±0.005	200.1	0.245	0.012
4	4^0 48.091N 6^0 19.554E	0.020±0.008	0.022±0.005	21.0.006	182.7	0.224	0.011
5	4^0 48.046N 6^0 19.484E	0.013±0.006	0.020±0.007	17.0±0.006	147.9	0.181	0.009
6	4^0 48.091N 6^0 19.499E	0.017±0.007	0.022±0.006	20.0±0.006	174.0	0.213	0.011
7	4^0 48.143N 6^0 19.442E	0.017±0.008	0.014±0.004	16.0±0.006	139.2	0.171	0.009
	ICRP STD	0.013	0.013	13	84	1	0.29

Table6. *Female Hostel Zone F*

S/N	Geological Location	Exposure Rate (mRh^{-1})	Exposure Rate (mRh^{-1})	Average Exposure Rate (μRh^{-1})	Dose ($nGyh^{-1}$)	AEDE ($mSvy^{-1}$)	ELCR $x10^{-3}$
1	4^0 47.870N 6^0 18.981E	0.020±0.006	0.019±0.005	20.0±0.005	174.0	0.213	0.011
2	4^0 47.880N 6^0 19.007E	0.018±0.005	0.012±0.007	15.0±0.006	130.5	0.160	0.008
3	4^0 47.847N 6^0 19.006E	0.016±0.008	0.029±0.007	23.0±0.007	200.1	0.245	0.012
4	4^0 47.843N 6^0 18.967E	0.016±0.004	0.013.009	15.0±0.006	130.5	0.160	0.008
5	4^0 47.890N 6^0 18.955E	0.018±0.003	0.019±0.002	19.0±0.002	165.3	0.203	0.010
6	4^0 47.930N 6^0 18.955E	0.016±0.003	0.014±0.008	15.0±0.006	130.5	0.160	0.008
7	4^0 47.822N 6^0 19.068E	0.011±0.007	0.011±0.005	11.0±0.006	95.7	0.117	0.006
	ICRP STD	0.013	0.013	13	84	1	0.29

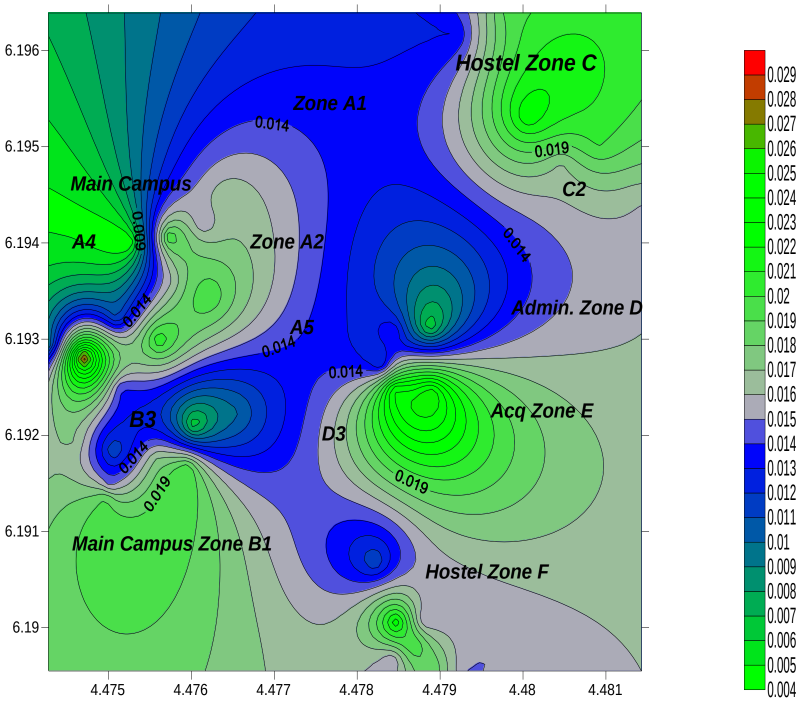

Fig2. *Contour map showing distribution of BIR*

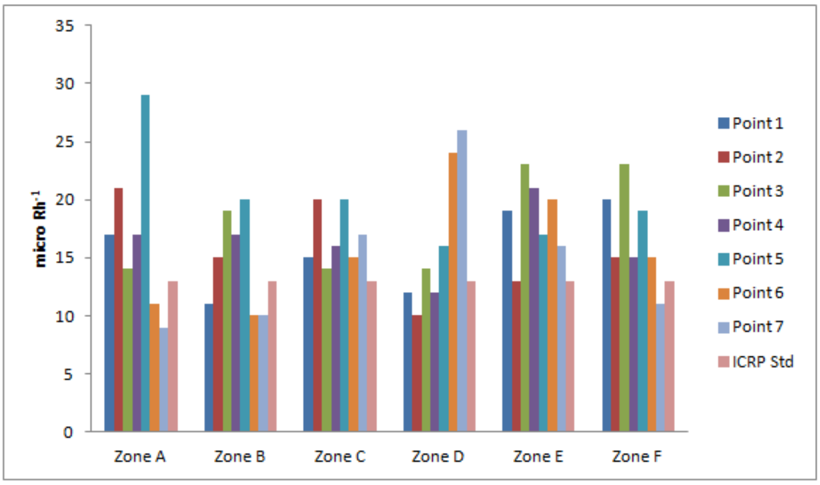

Fig3. *Comparison of average Exposure levels with the ICRP standard*

3.2. Discussions

Environmental radioactivity assessment was conducted within the Federal University Otuoke using Radalert-100 and Digilert-200 radiation meters followed by mathematical computation of hazard indices. The results are recorded in tables 1 to 6. The average exposure rate at most points of measurement exceeded the world permissible rate of 13μRh^{-1}.These values are however in agreement with previously reported results by [14]. Figure 3 shows the comparison of exposure levels with the world permissible limit of 0.013mRh^{-1}. Figure 4 shows the contour map distribution of background ionizing radiation (BIR). The highest average exposure rate was recorded at the fifth point of measurement in zone A. Zone C shows uniform BIR values. Computed annual effective dose equivalent and excess lifetime cancer risk were found to be below the recommended permissible limits. Dose rate at most points of measurement exceeded the recommended permissible dose of 84nGy^{-1}, similar to [15].This study serves as caution to improving public health through the information that TENORMs need not be added to this University community.

4. Conclusion

The environmental radioactivity profile of the Federal University Otuoke showed that the background ionizing radiation (BIR) levels exceeded WHO standard BIR level of 0.013mRh^{-1}. Radiological health hazard indices varied at many points of measurement. The elevated BIR may be attributed to oil and gas activities in nearby communities. Generally speaking the values of the hazard indices were not at alert levels when compared with internationally recommended standards such as International Commission on Radiation Protection (ICRP) and United Nations Scientific Committee on the Effect of Atomic Radiation, however regular monitoring is recommended as no amount of ionizing radiation is desirable.

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