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EVALUATION OF BACKGROUND IONIZING RADIATION IN PRIVATE TANK FARMS IN PORT HARCOURT.

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Abstract
A Geographical positioning system (GPS) based *in-situ* measurement of background ionizing radiation of two private tank farms in Port Harcourt was conducted using well-calibrated radiation meters (Digilert–50 and Radalert-100). In each of the tank farms, eleven sampling points were randomly identified and the exposure rate was measured within each geographical location. The exposure rate measured in tank farm one (1) ranges from 0.010 ± 0.003 mRh^{-1} to 0.028 ± 0.004 mRh^{-1} with an average value of 0.019 ± 0.003 mRh^{-1} while that of tank farm two (2) ranges from 0.011 ± 0.001 mRh^{-1} to 0.021 ± 0.008 mRh^{-1} with an average value of 0.016 ± 0.005 mRh^{-1}. The mean absorbed dose, annual effective dose equivalent (AEDE) and excess lifetime cancer risk (ELCR) in tank farm 1 are 137.6±9.80 $nGyh^{-1}$, 0.211± 0.018 $mSvy^{-1}$ and $0.738 \pm 0.053 \times 10^{-3}$ while the mean absorbed dose, AEDE and ELCR in tank farm 2 are 143.2±7.28 $nGyh^{-1}$, 0.220± 0.019 $mSvy^{-1}$ and $0.738 \pm 0.053 \times 10^{-3}$ respectively. The absorbed dose, Annual effective dose equivalent and excess lifetime cancer risk in tank farm 1 and tank farm 2 when compared with the united nation scientific committee on the effect of atomic radiation (UNSCEAR) standard of 84.0 $nGyh^{-1}$, 1.0 $mSvy^{-1}$ and 0.29×10^{-3} exceeded the permissible limit of absorbed dose and excess lifetime cancer risk while the value for AEDE is within the world safe value. The overall result shows that the background ionizing radiation level of the two tank farms has been elevated above safe values

Keywords: Radiation, Exposure-rate, Absorbed-dose, Cancer Risk

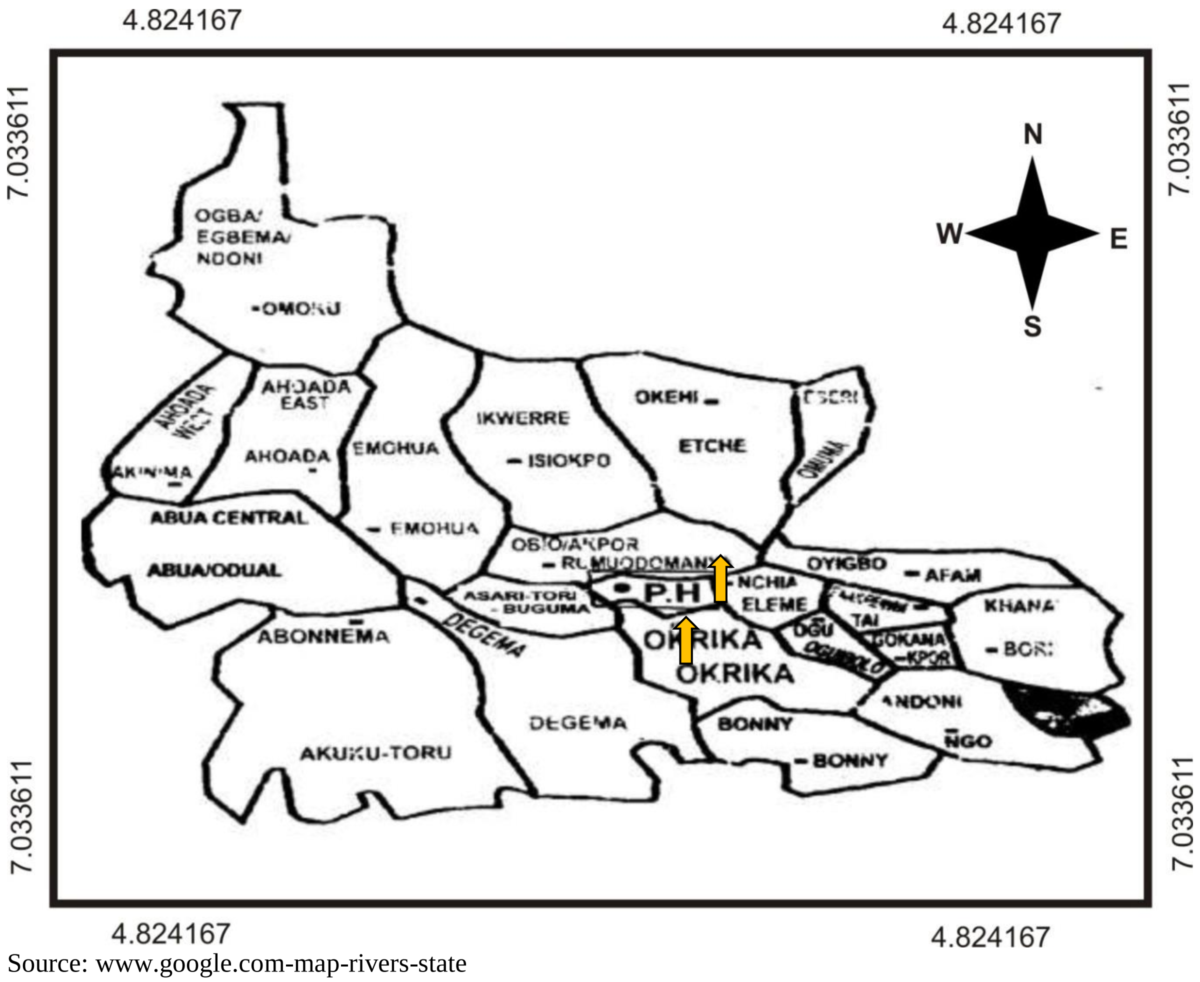
Introduction

The tank farm is a synonym for an oil depot, a facility for the storage of liquid chemicals, such as oils, gasoline, diesel, aviation turbine fuel, solvents and petrochemicals (Angan et al., 2011). The tank farm is usually situated close to oil refineries or locations where marine tankers containing products can discharge their cargo. However, during the discharge of petroleum products and petrochemical products in the tank farm there is an emission of radiation.Radiation is the emission of streams of particles such as an electron, protons, high-energy photons or an emission combination of these (Parker, 1989). It is also defined as the emission of radionuclide particles in form of electromagnetic waves.The exploitation and exploration of crude oil and gas activities increase the levels of background ionizing radiation in the tank farm and may cause some health effects on workers, personnel and the host communities as well.Radiation emissions have been associated with crude oil and its associated products (Arogunjo et al., 2004). Several categories of workers such as tanker drivers, conductors, mechanics, pump attendants and service personnel work daily on the tank's farm, some spending days and weeks in the environment, especially during the period of petroleum products scarcity.

The problem of exposure to an unnoticed rise in the background ionizing radiation of the environment is one of the major issues that bring difficulties in handling the effect which arises from high background ionizing radiation Sigalo, (2000). During the loading and offloading of crude oil products in the tank farm workers could be exposed to health hazards and effects which may result in various sicknesses such as skin cancer, mental disorder, genetic mutation, eye cataracts, leukaemia, haematological depression and incidence of chromosome aberration (EPA, 2009). Hence this study becomes necessary.

Tank farms are mostly called oil depots, installation points or oil terminals. It is an industrial facility for the storage of oil, gas and petrochemical products and from which these aforementioned products are usually transported to end users or further storage facilities (Daniel et al, 2002).The storage tanks may be used to store base blending components, solvents, additives, acids, caustic, chemicals, or finished products. They may also be used as blending vessels (Angan et al., 2011).The oil depot or tank farms have tankage either above the ground or underground, and gantries which are frameworks for the discharge of products into the road tankers or other vehicles (such as barges) or pipelines. However, some depots are attached to pipelines from which they draw their supplies. Most of the products reaching tank farms are already processed to their final form suitable for delivery to customers. Modern tank farm comprises tankage, pipelines and gantries in greater automation on site.

Fig: 1. Map of the Study Area



Source: www.google.com-map-rivers-state

Study Area

The study area comprises of two local government areas in Rivers State. Obio-Akpor and Port Harcourt Local Government in Rivers State. The two tanks farms are oil servicing companies located in Rumuolumeni Industrial Layout, Port Harcourt, Rivers State and Reclamation Road, Old Port Harcourt Town, River among other multinational oil companies which contain a lot of tank farms both on and off-shore in Rivers State.

Materials and Methods

The research on the background ionizing radiation in private tank farms encompasses the use of radiation monitor devices such as Digilert 50 and Radalert 100 in addition to the Geographical Positioning System (GPS). The radiation meter used is capable of detecting ionizing radiation within the temperature range of -10 to 50^0. The area lies within a longitude of E$7^0$2'0.9996'' and a latitude N$4^0$49'27.0012''. The study area is Obio-Akpor and Port Harcourt Local Government Area, in Rivers State. Port Harcourt has 19 oil depots and was known as a base for crude oil activities and also oil companies' industrial base.The data collection was carried out after the radiation-detecting meters were reset to give the expected readings with the required units. During the measurements in the fieldwork, the tube of radiation meters is placed at a standard distance of 1.0m above the ground and placed also at about 2.0m to 2.5m away from the facilities. Their windows are first oriented vertically downwards and then towards the facility. The geographical location of the particular facility is determined and recorded with the help of geographical positioning system (GPS) Paschola (1997). The meters are placed horizontally above the level of about 1.0m above the ground while the reading is recorded twice to have an accurate reading of the background ionizing radiation of the facilities (IAEA, 2013). At each facility, two different readings are obtained within a time interval of 5mins and their mean value is recorded. In a given field, ten different facilities at different spots were surveyed to ensure adequate coverage and finally, a radiation profile of the host community is also obtained. The experimental and surveyed activities were carried out between the hour of 11:0 clock and 2:20 pm in tank 1 located in Port Harcourt, similarly, tank 2 located also in Obio-Akpor was surveyed between the hour of 11:45 am to 2:30 pm respectively.The collected data for absorbed dose was calculated using the formula given as 1μR/h = 8.7nGy/h = 8.7x$10^{-3}\mu$Gy/(1/8760)yr - (1) Fujimoto, et al., (1985).

Absorbed Dose (D): Absorbed dose is a measure of the quantity or amount of ionizing radiation that a substance or material absorbed. When ionization radiation strikes a material, it will deposit energy in that material through a variety of interactions (Mujahid et al., 2008). Absorbed dose (D) is also the quantity of energy deposited per unit of mass as a result of the interplay of ionizing radiation which includes neutron radiation and matter. The unit of absorbed dose is the grey (Gy), which by measure is equal to an energy deposition of 1J/Kg (Avwiri, G.O. 2011).

Annual Effective Dose Equivalent (AEDE): Radiations of various types have different effects on tissue. To account for these differences, the absorbed dose is multiplied by a radiation weighting factor (IAEA, 1999). This factor is dependent upon the type and amount of radiation factor 0.7Sv/Gy and the occupancy factor for the outdoors of 0.25. Occupancy factors for the outdoor situation were calculated based on the measurements and records.

AEDE Outdoor (mSvy^{-1}) = Absorbed Dose Rate (nGy/h) x 8760h x 0.7Sv/Gy x 0.25). – (2)

The hour spent was about 3hrs in the study area.

In the UNSCEAR, 1993 report, the committee used 0.7Sv/Gy for the conversion coefficient from the absorbed dose in the air to the effective dose received by adults (Muhammed et al., 2014).

Excess Lifetime Cancer Risk (CLCR): This is a potential carcinogenic effect that is characterized by estimating the probability of cancer incidence in a population of individuals for a specific lifetime from projected intakes of ionizing radiation exposures and chemical-specific dose response dates (Laogun et al., 2006).

Based upon calculated values of AEDE, excess lifetime cancer risk (ELCR) is calculated using the equation given below:

ELCR = AEDE x Average Duration of Life (ΔL) x Risk Factor (RF) - (3)

Where:

AEDE and RF are the annual effective dose equivalent, duration of life (70) years and risk factor or fatal cancer risk per Sieviet. For low-dose background radiations which are considered to produce stochastic, ICRP 60 uses a value of 0.05 for public exposure (Ononugbo et al., 2015). The result of the experiment recorded is high.

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Results

The result of the background ionizing radiation (BIR) in Tank Farm 1 is shown in table 1.1, which analyzed the radiation risk parameters with the exposure rate of the area.

Table 1. Background Ionizing Radiation in Tank Farm 1

S/N	Sampled Area	Geographical Location	Exposure Rate (mRh^{-1})		Av. Exposure Rate (mRh^{-1})	Absorbed Dose (nGyh^{-1})	Annual Effective Dose Eqv (AEDE) (mSvy-1)	ELCR (x10^{-3})
			Rad 50	Rad100				
1	AGO Pump House	N04^{0}45^{0}421’ E007^{0}00.486’	0.013	0.017	0.015±0.002	130.5±2.14	0.200±0.003	0.700±0.012
2	Loading Area	N04^{0}45^{0}364’ E007^{0}00.515’	0.033	0.022	0.028±0.004	243.6±31.96	0.373±0.049	1.306±0.171
3	AGO Area	N04^{0}45^{0}317’ E007^{0}00.560’	0.011	0.019	0.015±0.002	130.5±2.14	0.200±0.003	0.700±0.012
4	ENG	N04^{0}45^{0}317’ E007^{0}00.589’	0.021	0.020	0.021±0.003	182.7±13.60	0.280±0.021	0.980±0.073
5	STORE	N04^{0}45^{0}341’ E007^{0}00.593’	0.018	0.020	0.019±0.003	165.3±8.35	0.253±0.013	0.886±0.045
6	OFFICE	N04^{0}45^{0}372’ E007^{0}00.498’	0.016	0.014	0.015±0.002	130.5±2.14	0.200±0.003	0.700±0.012
7	RECEPTION	N04^{0}45^{0}409’ E007^{0}00.516’	0.013	0.013	0.013±0.003	113.1±7.39	0.173±0.012	0.606±0.040
8	ENTRANCE	N04^{0}45^{0}413’ E007^{0}00.541’	0.013	0.011	0.012±0.001	104.4±10.01	0.160±0.003	0.560±0.054
9	BULK CLINIC	N04^{0}45^{0}385’ E007^{0}00.517’	0.010	0.010	0.010±0.003	87.0±15.26	0.133±0.024	0.466±0.082
10	CANTEEN	N04^{0}45^{0}408’ E007^{0}00.508’	0.016	0.012	0.014±0.003	121.8±4.76	0.187±0.007	0.655±0.025
11	COMMUNITY	N04^{0}45^{0}476’ E007^{0}00.404’	0.012	0.012	0.012±0.001	104.4±10.01	0.160±0.033	0.560±0.054
	MEAN VALUE				**0.024±0.003**	**137.6±9.80**	**0.211±0.018**	**0.738±0.053**
	UNSCEAR (2000)					**84.0**	**1.0**	**0.29**

Result of Tank Farm 2

The result of the BIR in Tank Farm 2 is shown in table 1.2, which analyzed the radiation risks parameters with the exposure rate of the area.

Table 1.2: Background Ionizing Radiation in Tank Farm 2

S/N	Sampled Area	Geographical Location	Exposure Rate (mRh^{-1})		Av. Exposure Rate (mRh^{-1})	Absorbed Dose (nGyh^{-1})	Annual Effective Dose Eqv (AEDE) (mSvy-1)	ELCR (x 10^{-3})
			Rad 50	Rad100				
1	AMALCABLE	N04^{0}46^{0}286’ E006^{0}58.445’	0.021	0.019	0.020±0.0015	174.0±9.29	0.267±0.014	0.935±0.050
2	Generator House	N04^{0}46^{0}229’ E006^{0}58.444’	0.013	0.015	0.014±0.0003	121.8±6.45	0.187±0.001	0.655±0.034
3	Product Pump House	N04^{0}46^{0}301’ E006^{0}058.445’	0.020	0.022	0.021±0.0081	182.7±11.90	0.280±0.010	0.980±0.064
4	MEH 06	N04^{0}46^{0}314’ E006^{0}58.445’	0.011	0.010	0.011±0.0012	95.7±14.32	0.147±0.022	0.515±0.077
5	Lab Unit	N04^{0}46^{0}285’ E006^{0}58.441’	0.016	0.018	0.017±0.0057	147.9±1.42	0.227±0.071	0.795±0.008
6	Reception	N04^{0}46^{0}308’ E006^{0}58.425’	0.014	0.020	0.017±0.0057	147.9±1.42	0.227±0.071	0.795±0.008
7	Entrance	N04^{0}46^{0}285’ E006^{0}58.423’	0.015	0.017	0.016±0.0031	139.2±1.21	0.213±0.002	0.746±0.007
8	Operation House	N04^{0}46^{0}332’ E006^{0}58.401’	0.018	0.018	0.018±0.0009	156.6±4.04	0.240±0.006	0.840±0.022

9	Office Entrance	N04^{0}46^{0}311' E006^{0}58.406'	0.011	0.012	0.012±0.0009	104.4±11.70	0.160±0.002	0.560±0.063
10	Clinic	N04^{0}46^{0}370' E006^{0}58.360'	0.020	0.022	0.021±0.0081	182.7±11.91	0.280±0.010	0.980±0.064
11	COMMUNITY	N04^{0}46^{0}404' E006^{0}58.340'	0.014	0.013	0.014±0.0003	121.8±6.45	0.187±0.001	0.655±0.034
	MEAN VALUE				**0.016±0.0033**	**143.2±7.28**	**0.220±0.019**	**0.769±0.039**
	UNSCEAR Standard (2000)					**84.0**	**1.0**	**0.29**

Fig 2: Comparison of Absorbed Dose in Tank Farm 1 with UNSCEAR Standard

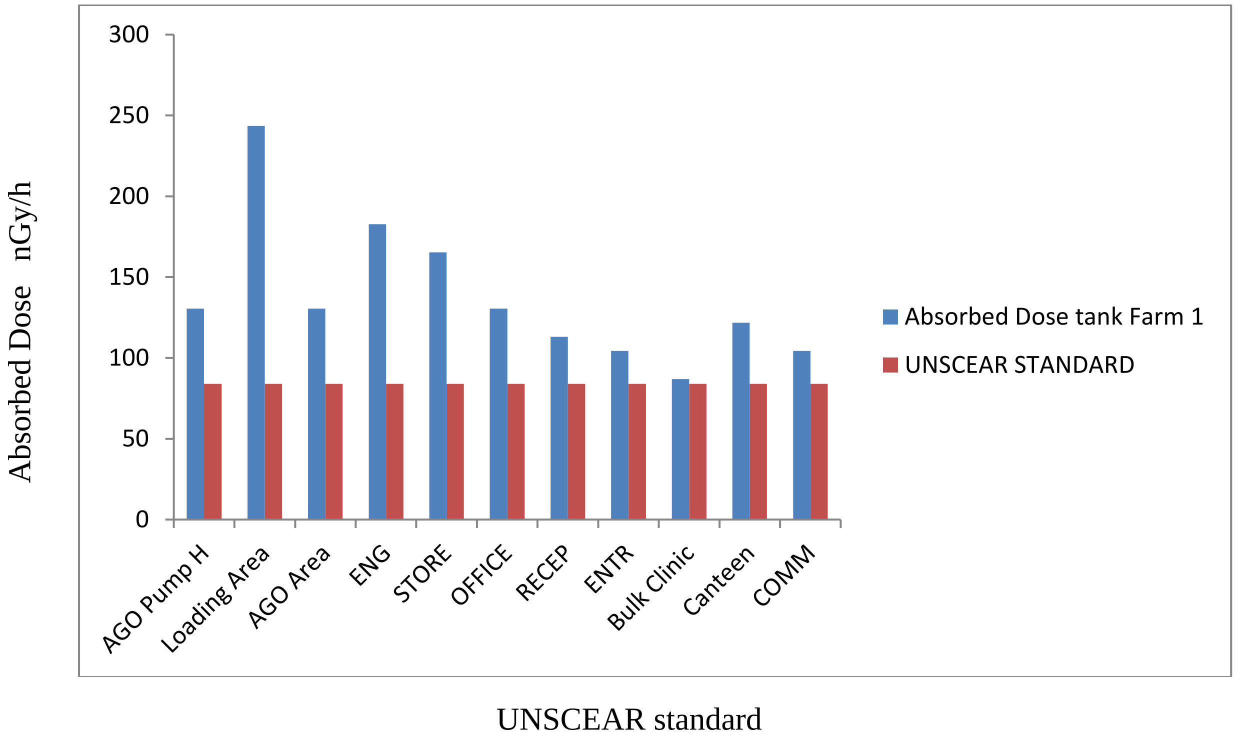

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Fig 3: Comparison of Annual Effective Dose Equivalent in Tank Farm 1 with UNSCEAR Standard

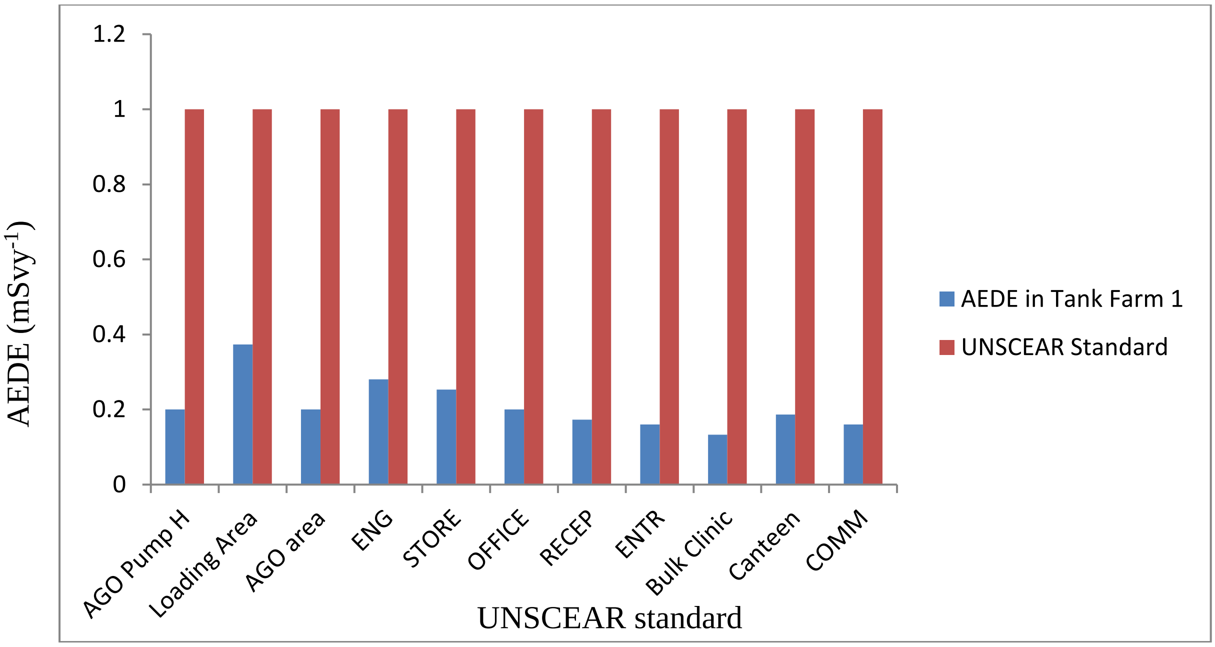


Fig .4: Comparison of Excess Lifetime Cancer Risk in Tank Farm 1 with UNSCEAR Standard

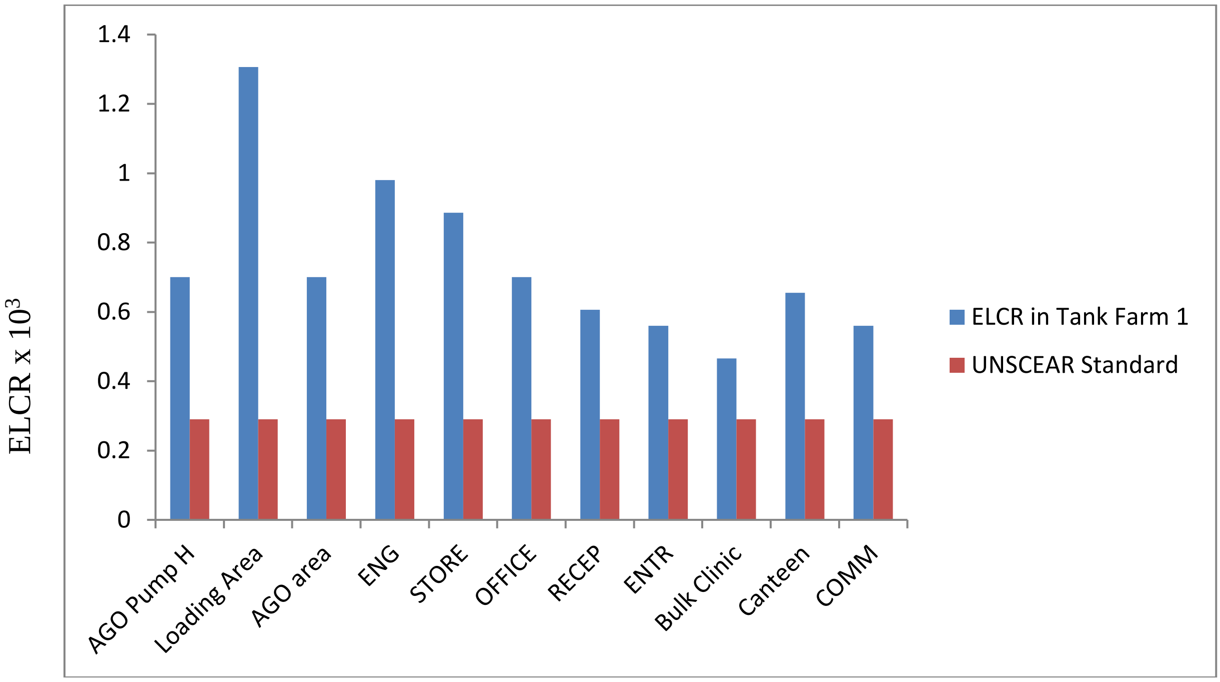
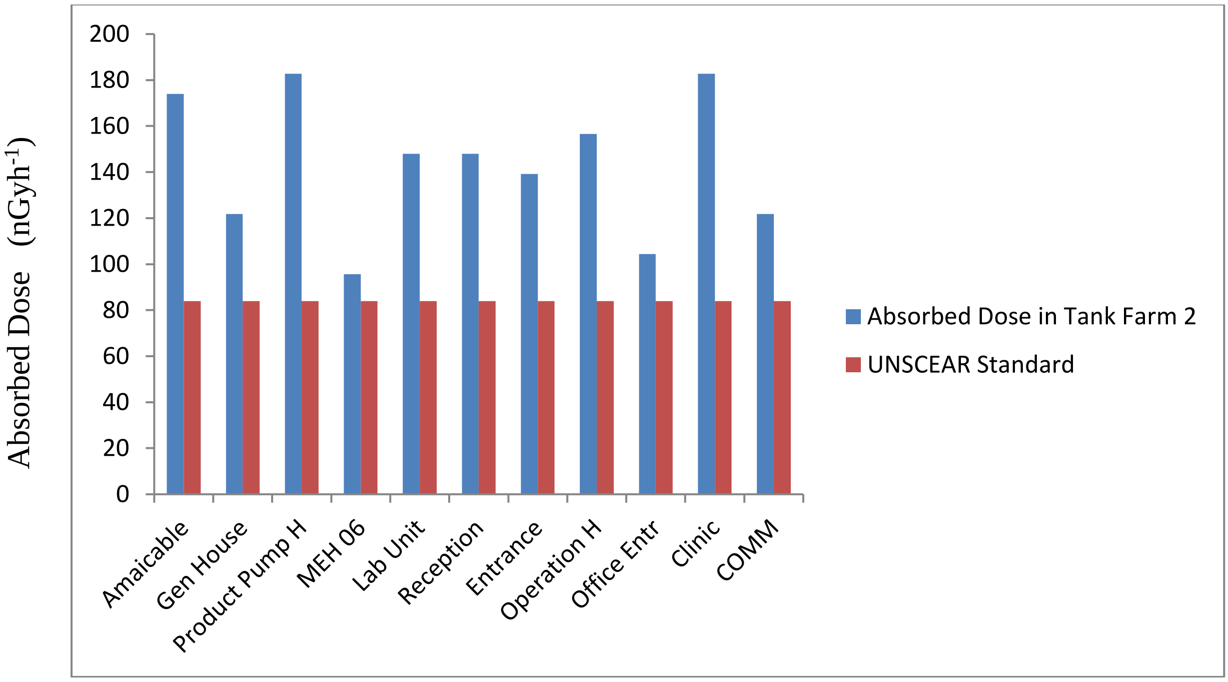


Fig 5: Comparison of Absorbed Dose in Tank Farm 2 with UNSCEAR Standard

UNSCEAR standard



UNSCEAR Standard

Fig 6: Comparison of Annual Effective Dose Equivalent in Tank Farm 2 with UNSCEAR Standard

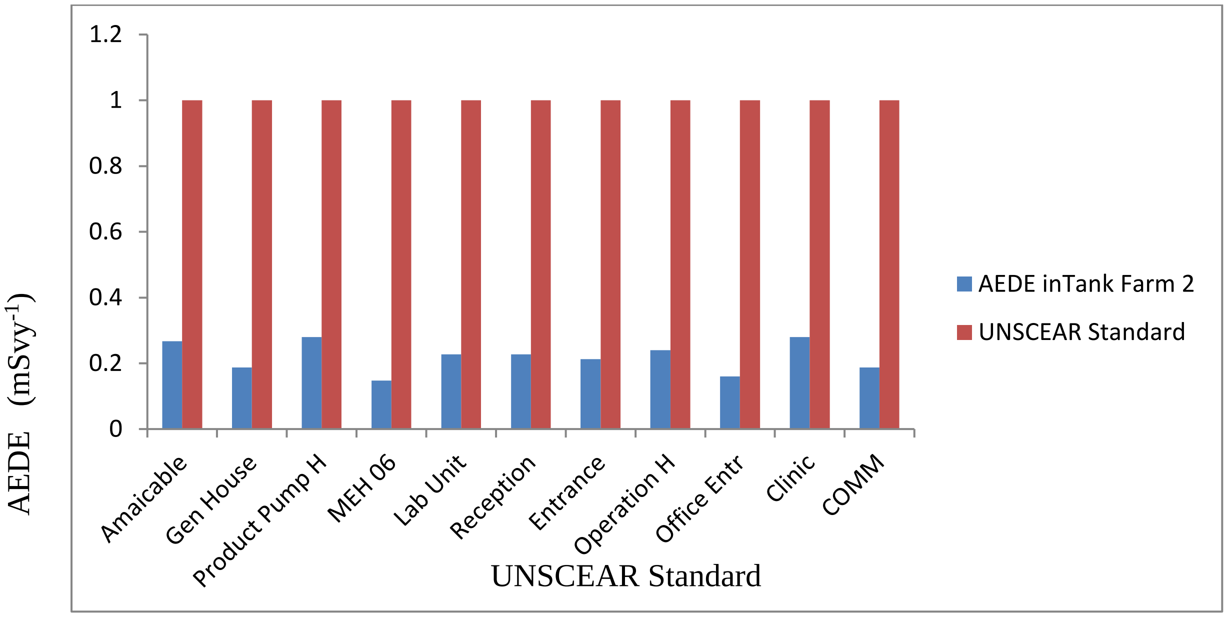


Fig 7: Comparison of Excess Lifetime Cancer Risk in Tank Farm 2 with UNSCEAR Standard

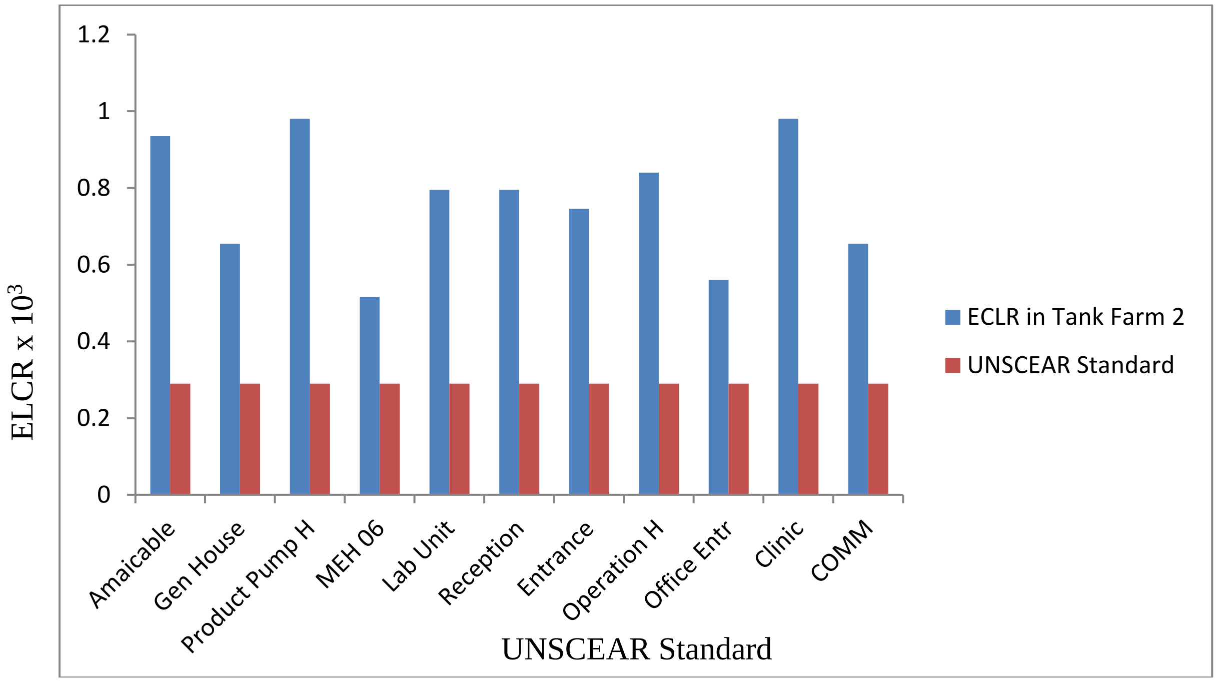


Fig 8: Chart showing the absorbed dose in Tank Farm 1 with UNSCEAR Standard

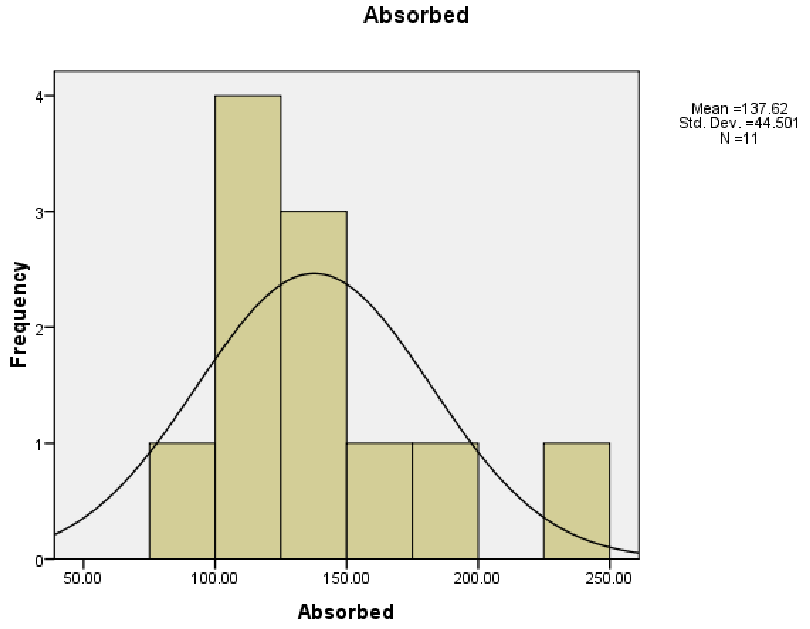
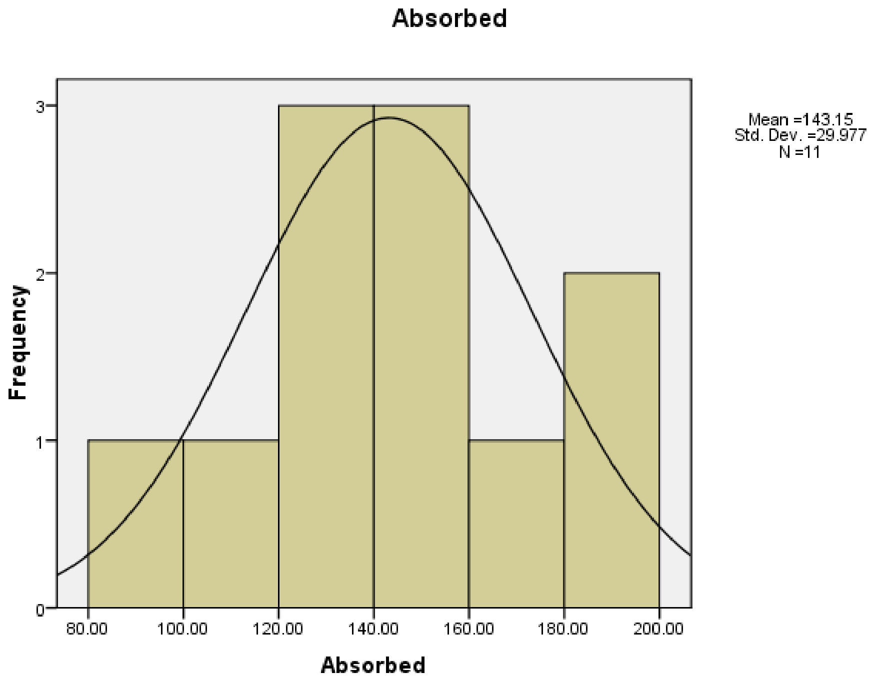


Fig 9: Chart showing the absorbed dose in Tank Farm 2 with UNSCEAR Standard



Discussion

The mean value of the average exposure rate, absorbed dose, annual effective dose equivalent (AEDE) and ELCR compared with the UNSCEAR Standard is shown in Tables 1 and 2. It was clear that the level of radiation activities in the two tank farms is grossly higher than permissible.The mean radiation exposure rate in the tank farms ranged from 0.028 ± 0.004 mRh^{-1} to 0.010 ± 0.003 mRh^{-1} with the average value of 0.019 ± 0.0035 mRh^{-1} for the COPLC tank farm 1 and ranged from 0.021 ± 0.0081 mRh^{-1} to 0.011 ± 0.0012 mRh^{-1} with the average mean 0.016 ± 0.0047 mRh^{-1} for tank farm 2.The mean absorbed dose for tank farm 1 ranged from 243.6 ± 31.96 to 87.0 ± 15.26 with an average mean value of 137.6±9.80 while the mean absorbed dose in tank farm 2 ranged from 182.7±11.90 to 95.7±14.32 with the average mean value 143.2±7.28 $nGyh^{-1}$ when compared with the UNSCEAR standard of 84.0 $nGyh^{-1}$ exceeded the permissible limit.The mean value for AEDE and excess lifetime cancer risk (ELCR) in tank farm 1 and tank farm 2 are 0.211±0.018 $mSvy^{-1}$, 0.738±0.053 x 10^{-3} in tank farm1 and 0.220±0.019 $mSvy^{-1}$, 0.769±0.039 x 10^{-3} in tank farm 2 respectively. The mean values when compared with the UNSCEAR standard value of 1.0$mSvy^{-1}$ and 0.29 x 10^{-3} respectively, it was observed that the AEDE value is within the permissible value while the excess lifetime cancer risk exceeded the limit value, showing possible high cancer risk in the area. The result in Figure 2 to Figure 4 shows the comparison with the standard value in tank farm 1 and the peak value for absorbed dose in Figure 4 is observed at the loading area of the tank farm while Figure 5 to Figure 7 shows the comparison with standard value in tank Farm 2. Having the highest absorbed dose in Figure 5 at the product area and clinic centre in the tank farm.The study when compared with other research work, (Avwiri et al., 2017) was within the international standard values. Thus there should be strict monitoring of radiation levels and works placed on shifting bases (Abu-Jarad et al., 2007). There is the probability of cancer health hazards and other radiation sicknesses as proposed.

Conclusion

Two private tank farms have been identified in Port Harcourt, Rivers State of Nigeria. The background ionizing radiation has been measured in tank farm 1 and tank farm 2 as shown in Table 1.1 and Table 1.2 with the mean shown. The exposure rate measured in tank farm 1 ranges from 0.028 ± 0.004 mRh^{-1} to 0.010 ± 0.003 mRh^{-1} with the average value of 0.019 ± 0.0035 mRh^{-1} for tank farm 1 and ranged from 0.021 ± 0.0081 mRh^{-1} to 0.011 ± 0.0012 mRh^{-1} with the average mean 0.016 ± 0.0047 mRh^{-1} for tank farm 2. The result recorded from the tank farms shows that absorbed dose and excess lifetime cancer risk in these farms exceeded their world safe values of 84.0 $nGyh^{-1}$ and 0.29 x 10^{-3} while the annual effective dose equivalent values recorded is within the world safe value recommended by ICRP. Hence the results show that the tank farms have contributed negatively to the environment and the field workers including host communities. The negative impact of the tank farms could result in health effects such as eye cataracts, hereditary challenges, skin cancer, and sterility among others.

Recommendations

The research ends with some recommendations**:**

i. Oil and gas tank farm workers should undergo radiation training on the danger of radiation exposure.
ii. Instant dose meters should be given to all tank farm workers to help monitor their radiation doses as a means of management tool.
iii. Tank farm workers should have a routine check on their tanks and pipes to avoid unnecessary leakage of products
iv. There should be regular monitoring of BIR levels in the companies, possibly creating a reporting office on radiation impact in the companies
v. Time spent on tank farms should be reduced to minimize radiation exposure.

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