Evaluation of Background Ionizing Radiation and Its' Associated Health Hazards in Onne Port Complex Port Harcourt

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Abstract
Exposure to background ionizing radiation has been a major challenge in the industry and transport sector. This study presents the results of outdoor ambient dose rates in and around Onne port complex, Eleme, Port Harcourt Rivers State, Nigeria. An In-situ measurement of radiation exposure rate was done using well calibrated radiation detector (Radalert-100). From the exposure rate, the absorbed dose and cancer risk were calculated by standard methods. Results showed that the outdoor absorbed dose rates ranged between 165.7 nGy/h to 55.26 nGy/h, while values obtained from ISL, PCL, GLT, GTT, RJOT, JYT, MKT, WST & FST premises are above the UNSCEAR 2008 standard. The calculated excess lifetime cancer risk ranges between 0.509 and 0.17. The study concluded that the radiological risk parameters calculated from the port complex are above the recommended world standards by ICRP and UNSCEAR, and the onne complex is not radiologically degraded.

Introduction

Exposure and over-exposure of humans to ionizing radiation could lead to different health effects or challenges on the populace irrespective of their age, gender, and occupations. Radiation as part and parcel of the human environment is present everywhere, but the quantity or level varies from place to place depending on the types of man-made activities, natural activities and bedrocks in a given environment media. The ionizing radiation in a given environment is also regarded as background ionizing radiation. Background radiation is the radiation that is always present in the environment, it includes; cosmic radiation from the sun, and stars, terrestrial radiation from the earth, and internal radiation in living matter (NRC 2021). The bulk of background radiation occurs naturally from radioactive minerals in the ground, soil and water. Cosmic rays, radioactive element in the earth crust and solar radiation contributes to background radiation around humans (EPA, 2023). Humans are exposed to ionizing radiation from different sources or pathways such as exposure from cosmic radiation, terrestrial radiation, inhalation and ingestion (UNSCEAR 2009). Terrestrial radiation varies from place to place depending upon the variation of radionuclide concentration in soil. Humans are exposed to outdoor radiations from the natural terrestrial radiation that originates predominantly from the upper 30cm of the soil (Shanthi *et al*, 2009; Avwiri, 2012). Other sources of exposure are industrial, medical, atmospheric testing, nuclear fuel cycle. In recent years, radiation pollution has become major issue to physicists in particular and scientists and environmentalists in general. Both the type of radiation, sources of radiations, uses and their interactions with matter has been the most fascinating aspect in our day-to-day activities, ranging from the manufacturing, oil and gas, food industries, and land, sea and air transport sectors. The use of radiation sources in fertilizer productions, in medical diagnosis and therapy have contributed to increase in background radiation and the radiation dose levels of many industrial workers (Avwiri, 2011; Ononugbo and Mgbemere 2016). Radiation is important to man and other creatures in their activities. Man is exposed to different types of radiations at different levels, or dosage. Man is exposed to radiations that are emitted by radionuclides in the environment (air, water and soil) during radioactivity, (UNSCEAR, 2009).

The study area, Onne Port complex is in Eleme Local Government Area of Rivers State, Nigeria, located in Onne town, east of Port Harcourt city at latitude 4.723816, & longitude 7.151618. It can receive large capacity cargo ships of over 60,000 tons. The port is strategically located in one of the largest Oil and Gas Free Zone in the world supporting exploration and production of oil for Nigerian activities. The free zone provides logistics to oil service Centres for the oil and gas industry in Nigeria both onshore & offshore. It also provides easy access to the entire West African & Sub-Sahara oil fields. Onne port is a multipurpose cargo port and accounts for over 65% of the export cargo through the Nigerian sea port, (NPA 2023). There are multiple operations that are carried out in the port, in addition to oil & gas operations. Such numerous operations include general cargoes, oil well equipment, bulk cargoes (wet & dry), containerized cargoes and logistics services are provided to companies and customers or tenants. The activities of West African Container Terminal, and government agencies like Nigerian Customs services are paramount in the port. As such the port is equipped with cargo scanner, which uses radiation. Nigerian customs service within the port manages the x – ray scanning machine that scan the cargo containers and others. The x – ray scanner and some oil and gas equipment that are transported through the complex uses radiation sources and this can impact on the port complex, workers and visitors.

This study aims at measuring the background ionizing radiation levels of Onne port complex and its environment and from the exposure rate, the absorbed dose of radiation, the annual effective dose and excess lifetime cancer risk associated with the exposure will be evaluated. This will help to determine the radiological burden on the environment and associated health risk. The result of this study will serve as a surveillance tool for radiation monitoring of the Port complex.

Avwiri *et al*; (2007) carried out terrestrial radiation survey around oil and gas facilities in Ughelli, Nigeria and obtained dose equivalent that were within the safe radiation limit. Avwiri and Ebeniro (1998) studied the external environmental radiation in an industrial area of Rivers state. The result showed that an average of 0.014mR/hr of background radiation was obtained, and the results are above the standard background radiation of 0.013mR/hr. Nwankwo and Akoshile, 2005;(Avwiri *et al*, 2012) monitored the external background radiation level in Asa Dam industrial area of Ilorin, Kwara State, Nigeria. The obtained results for the background ionizing radiation level of the studied area were above the recommend standard external radiation level. Ononugbo, and Mgbemere (2016) studied the Terrestrial gamma radiation in a Fertilizer Plant, Onne and the result showed that the exposure rate measured at the five sections of the plant exceeded the normal background radiation level. The estimated values of the absorbed dose and excess lifetime cancer risk were higher than the world acceptable value of 84 $nGyh^{-1}$ and 0.29 x 10^{-3} respectively.

Materials and Methods

Environmental radiation survey meter (Radalert-100) with halogen quenched GM tube detector with thin mica end window of density 1.5 – 2.0 mgcm-1 was used to measure natural background radiation dose rate. Radalert-100 radiation survey meter was calibrated to read exposure rate in two ranges with measuring sensitivity of 0.1 μRh^{-1} and 1.0 μRh^{-1} and exposure with measuring sensitivity of 1.0 μR and accuracy of ± 10% with ^{137}Cs (Rangaswamy *et al.*, 2016). The radiation meter is designed to serve as a low radiation level survey meter in indoor and outdoor environment. In addition to using equations 1 & 2, Wise Uranium calculator was also used to calculate the annual effective dose and excess lifetime cancer risk.

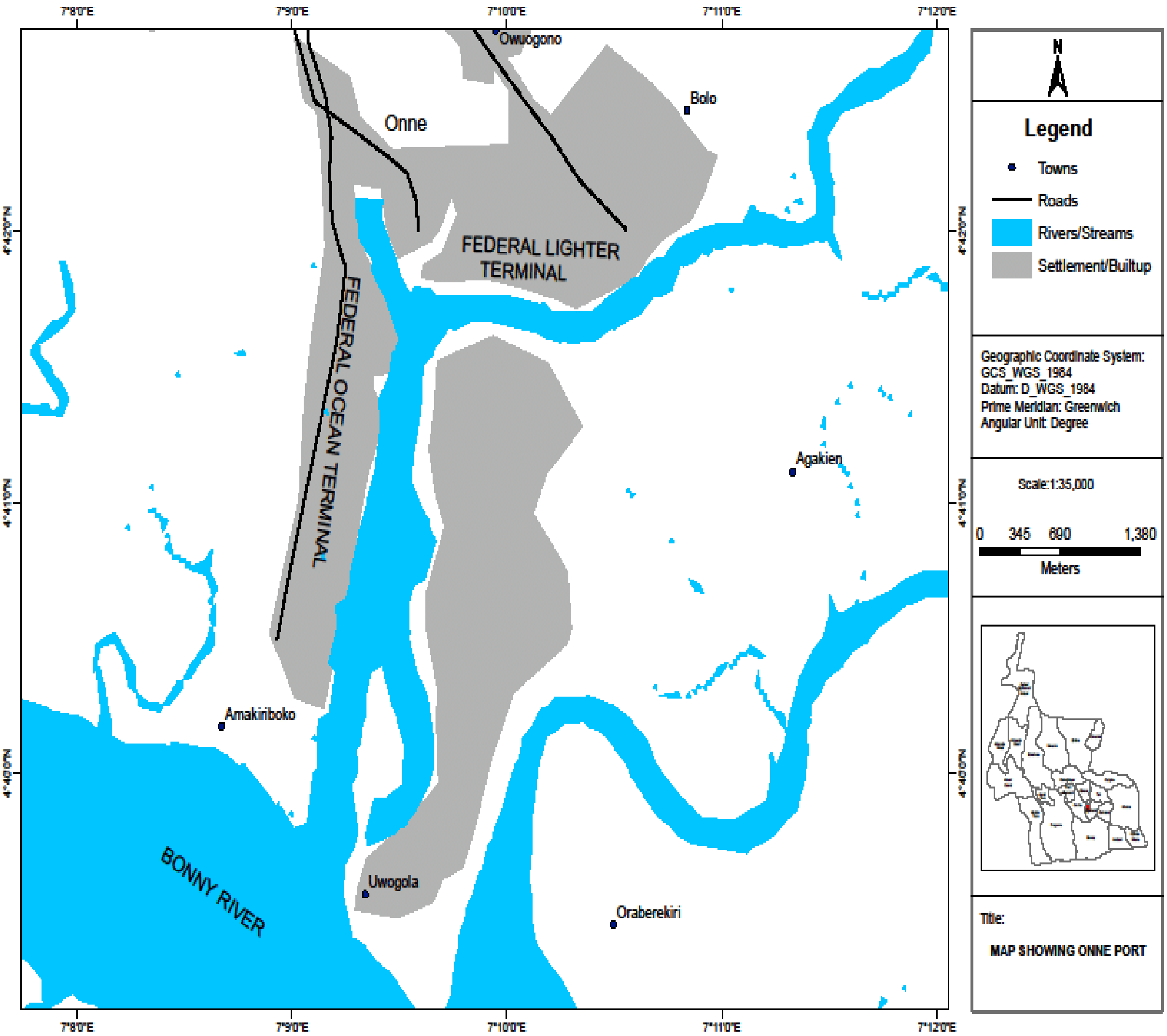

Fig Figure 1: Map of Onne Port Complex (Source: Research Gate, Adesola Ojesanmi, 2017.)

Radiological Hazard Indices

1. **Annual Effective Dose Equivalent (AEDE)**

The evaluated absorbed dose rate was used to calculate the annual effective dose equivalent (AEDE) received by people of surveyed area. For calculating AEDE, we used dose conversion factor of 0.7 Sv/Gy and the occupancy factor of 0.25 for outdoor exposure. The AEDE for the Outdoor terrestrial radiation was calculated using the equations given below (Rangaswamy et al., 2016; Muhammad *et al*., 2014; Ononugbo and Mgbemere, 2016).

AEDE (outdoor) ($mSvy^{-1}$) = D × T × OF × CC ------------------------ (1)

Where D is the absorbed dose rate, T is time in hours for 1 year (8760h), OF is the occupancy factor (0.25) for outdoor and CC is the conversion coefficient, in the UNSCEAR,1993 report, the committee used 0.7 Sv/Gy for the conversion from absorbed dose in air to effective dose received by adult population.

2. **Excess Lifetime Cancer Risk (ELCR)**

The Excess Lifetime Cancer Risk measures additional cancer risk induced by exposure to ionizing radiations. Based on the calculated values of AEDE, ELCR is calculated using the equation;

ELCR = AEDE x DL x RF --------------------------------------- (2)

Where AEDE is the annual effective dose equivalent, DL is the average duration of life (life expectancy) in Nigeria which is 54 years, (WHO, 2023) and, Rf is the risk factor given as 0.05 by UNSCEAR, 2000.

Results and Discussion

Table 1: Radiation Exposure of Onne Port Complex and its Radiological Parameters

S/N	Sampling Code	GPS Reading	Exposure Rates (mR/h)	Absorbed Dose (nG/h)	Annual Effective Dose (μSv/yr)	Excess Lifetime Cancer Risk (10^{-3})
1	CSL	N04˚41.804' E007˚10.423'	0.009	55.26	33.91	0.17
2	WEL	N04˚41.815' E007˚10.412'	0.011	67.54	41.44	0.207
3	ISL	N04˚41.811' E007˚10.387'	0.021	128.9	79.12	0.396
4	NSL	N04˚41.855' E007˚10.393'	0.01	61.4	37.67	0.188
5	LPL	N04˚41.873' E007˚10.367'	0.014	85.96	52.75	0.264
6	ABL	N04˚41.900' E007˚10.402'	0.015	92.11	56.51	0.283
7	SAL	N04˚41.927' E007˚10.406'	0.011	67.54	41.44	0.207

8	PCL	N04˚41.900' E007˚10.477'	0.027	165.7	101.7	0.509
9	EGL	N04˚41.914' E007˚10.520'	0.012	73.68	45.21	0.226
10	HEL	N04˚41.915' E007˚10.545'	0.015	92.11	56.51	0.283
11	GLT	N04˚43.161' E007˚09.399'	0.022	135	82.89	0.414
12	GTT	N04˚43.132' E007˚09.338'	0.018	110.5	67.82	0.339
13	RJOT	N04˚43.188' E007˚09.462'	0.021	128.9	79.12	0.396
14	JYT	N04˚39.984' E007˚08.888'	0.017	104.3	64.05	0.32
15	TST	N04˚40.029' E007˚08.863'	0.014	85.96	52.75	0.264
16	MKT	N04˚40.219' E007˚08.878'	0.019	116.6	71.59	0.358
17	WST	N04˚40.651' E007˚08.057'	0.022	135	82.89	0.414
18	FST	N04˚40.348' E007˚08.235'	0.018	110.5	67.82	0.339
19	DYT	N04˚40.617' E007˚08.282'	0.015	92.11	56.51	0.283
20	WAST	N04˚40.699' E007˚08.299'	0.012	73.68	45.21	0.226

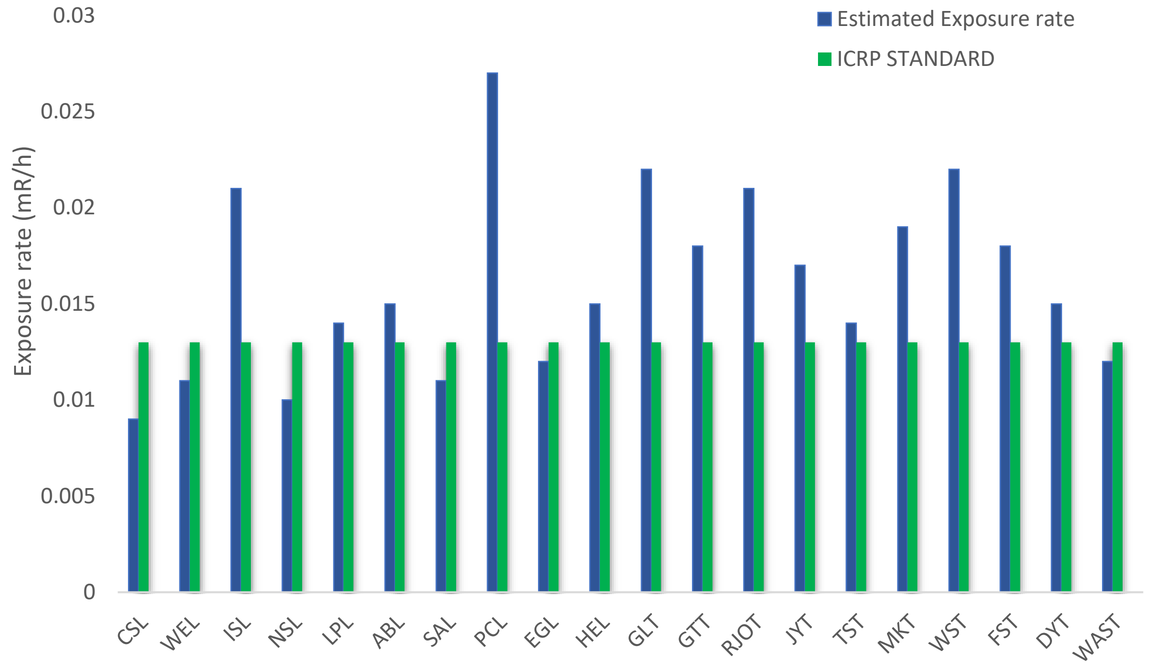

Fig 2: Comparison of Estimated Exposure rate with ICRP (2003) Standard

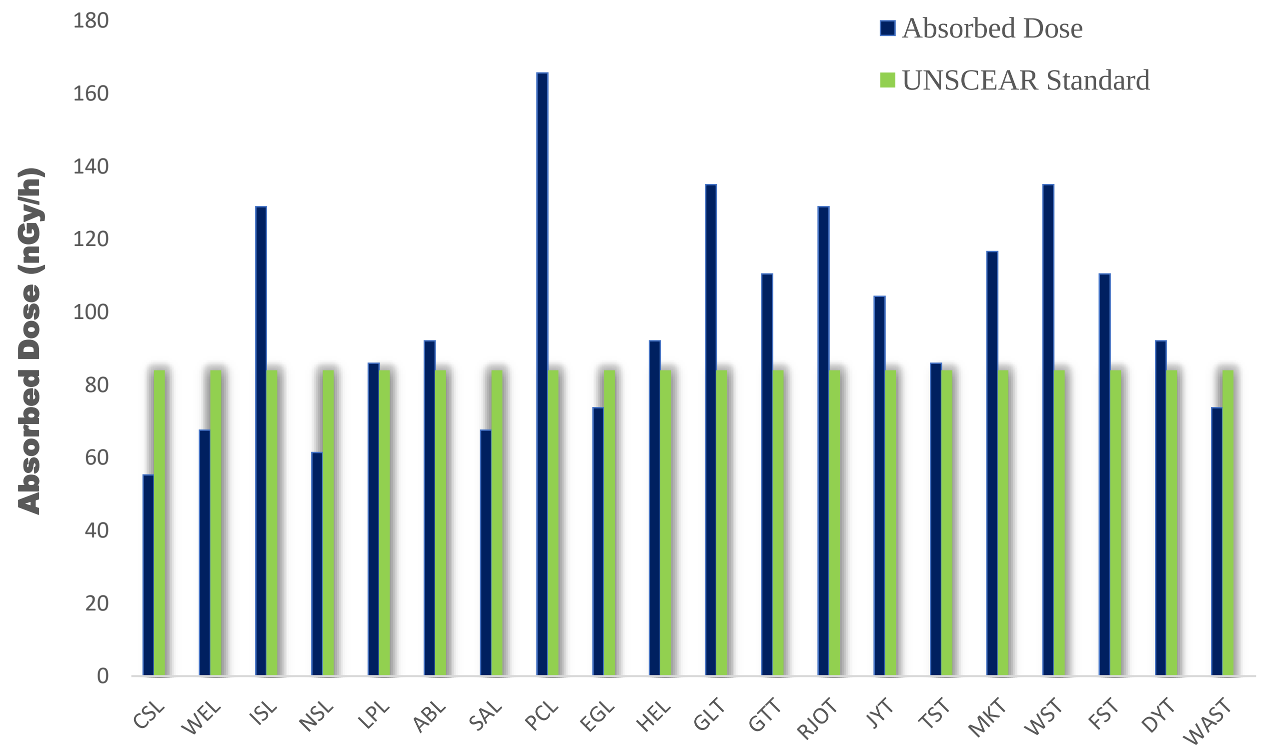

Fig 3: Comparison of Estimated Absorbed Dose with UNSCEAR (2008) Standard

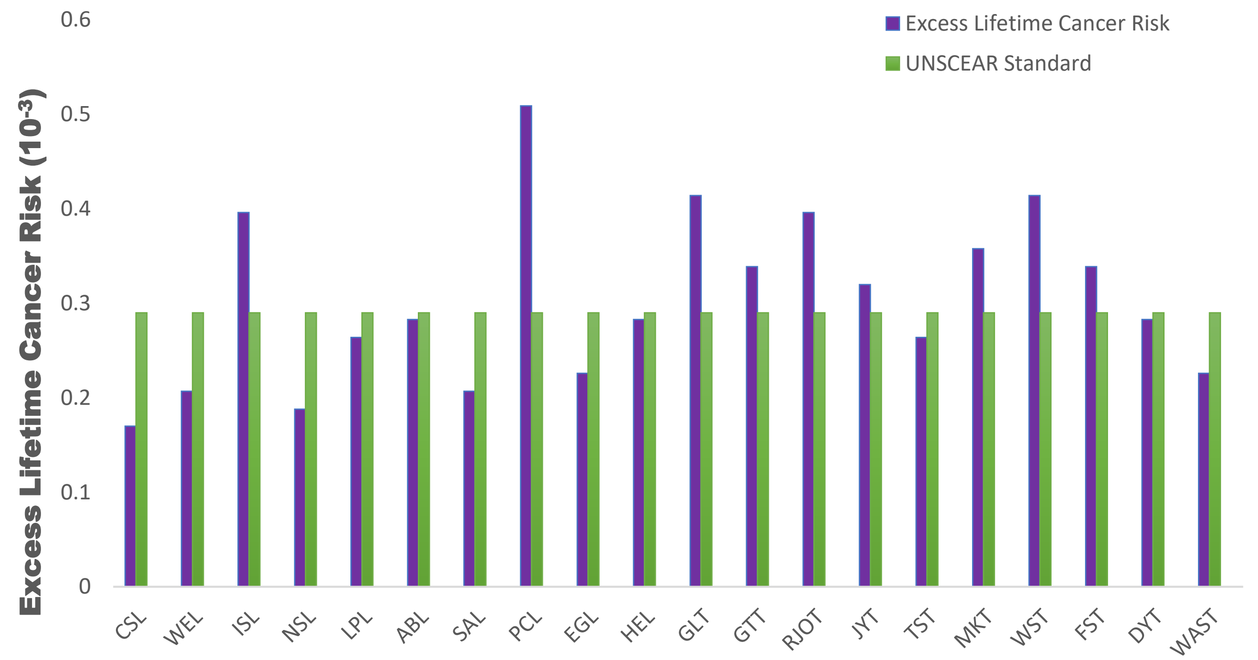

Fig 4: Comparison of Excess Lifetime Cancer Risk with UNSCEAR Standard

Results of the background ionizing radiation and associated radiological parameters of onne port complex are presented in Table 1, and the comparison of results with world standards are presented in Figures 2 to 4. The highest value of exposure rate, 0.027 mR/h was recorded at PCL premises followed by GLT premises with 0.022 mR/h and WST premises 0.022 mR/h. The background ionizing radiation exposure ranges between 0.027 mR/h to 0.009 mR/h. Comparison of estimated exposure rate with world standard indicates that more than 50% of the investigated areas have values that are above ICRP 2003 standard of 0.013 mR/h. The high values that are obtained from fourteen sites of the sampled areas, showed that the complex could be impacted seriously by background ionizing radiation and this is due to the oil and gas tools and Cargo container Scanning that are handled in the port complex by Nigerian Custom Services. Renato *et al* (2019), investigated Cargo and container inspection protocols at ports. The study focused on radiation dosimetry and potential application, while describing an in-situ set of radiation measurements from the surrounding of the scanning facility. The measurements were taken in two similar inspection facilities, aiming at both dosimetry purposes and possible deleterious effects to the personnel. The results suggested that the doses are below the limits accepted as tolerable considering occupational exposure, with values appearing as low as those recommended by international standards. The study concluded that as long as a proper procedure regarding the radiological protection plan is functional, such practice does not pose a significant radiological occupational risk. Ononugbo *et al* (2015) evaluated external ionizing radiation and estimated the health hazards and risks associated with exposure during the normal scanning operation and when the scanner is not in operation at the Nigeria Ports Authority, Onne seaport, Rivers State. The results obtained showed that the background ionizing radiation of the area has been impacted due to Cargo scanning operation.

The absorbed dose ranges between 165.7 nGy/h to 55.26 nGy/h at PCL and CSL respectively. The comparison between estimated absorbed dose and world standard, showed that the values obtained from ISL,128.9 nGy/h, PCL 165.7 nGy/h, GLT 135 nGy/h, GTT 110.5 nGy/h, RJOT 128.9 nGy/h, JYT 104.3 nGy/h, MKT 116.6 nGy/h, WST 135 nGy/h, and FST 110.5 nGy/h are above the UNSCEAR 2008 safety standard. These high values of absorbed dose rate which are above the world standard are in line with the high values that were obtained by Avwiri *et al*, (2012), in premium work in the same area. Also, Ononugbo *et al* (2015) affirmed that the average exposure rate and equivalent radiation dose obtained for each location of the study area (Onne Port complex) including office blocks are above the recommended safe value of $0.013mRhr^{-1}$ and $1.0mSvy^{-1}$ respectively. The results obtained showed that the background ionizing radiation of the area has been impacted, and this impact could be due to numerous activities by different companies and Cargo scanning Operations within the complex.

The calculated excess lifetime cancer risk showed that the occupants of the premises ISL, PCL, GLT, GTT, RJOT, JYT, MKT, WST and FST are exposed to values that are above the world recommended standard value of 0.29×10^{-3}. This result corresponded with high values obtained from a fertilizer plant in Onne by Ononugbo and Mgbemere (2016), thus the estimated values of the excess lifetime cancer risk were higher than the world acceptable value of 0.29×10^{-3}. The results obtained by this study are traceable to the activities of the oil and gas companies that uses the Onne port complex as the point of entering and exit of their operational tools and machines. Some areas with high values are as result of the activities in those areas such as the areas or premises where oil and gas equipment are stored, and the proximity to the X – ray scanner.

Conclusion

The evaluation of terrestrial ionizing radiation of Onne port complex was carried out using radiation meter, after which radiological parameters were calculated from the obtained exposure rate. The results showed that the premises: ISL, PCL, GLT, GTT, RJOT, JYT, MKT, WST and FST in the complex recorded very high values of absorbed dose and excess lifetime cancer risk which make these premises possibly unsafe radiologically. Hence the exposure rate and radiological parameters obtained are above the recommended world standards by ICRP and UNSCEAR.

The results revealed that Onne port complex as an area where different activities such as handling of oil and gas tools and equipment, cargo scanning, and containerized shipping takes place, is exposed to ionizing radiation. Therefore, workers, visitors and the environment in specific areas within the Onne port complex are exposed to ionizing radiation, which could lead to exposure to possible radiation health hazards.

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