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INVESTIGATION OF RADIOLOGICAL HEALTH INDICES FROM BACKGROUND IONIZING RADIATION LEVELS IN SWALI MARKET, YENAGOA, NIGERIA.

[1]Anekwe, U. L*. and [2]Olanrewaju A.I.

[1]Dept. of Physics, Federal University Otuoke, Bayelsa State, Nigeria.
[2]Dept. of Physics, Federal University of Kashere, Kashere, Gombe State.
***Correspondence Author:** uzanekwe@yahoo.co.uk

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ABSTRACT
Investigation of Radiological Health Indices from Background Ionizing Radiation levels in Swali Market was carried out using well-calibrated radalert-100 and 200 meters and a Global Positioning System (Garmin 765). The measured average exposure rates at seven different sections of the market were 0.017±0.005 mRh^{-1}(Entry point/market junction), 0.016±0.005 mRh^{-1}(Centre), 0.017±0.005 mRh^{-1}(Exit area), 0.018±0.003 mRh^{-1}(River bank), 0.016±0.004 mRh^{-1}(Dump area), 0.015±0.007 mRh^{-1}(Park zone) and 0.014±0.005 mRh^{-1}(Road side). The mean absorbed dose rates estimated in these sections of the market were 147.90, 142.68, 143.55, 158.78, 139.20, 132.68, and 118.90 nGy/hr respectively. Minimum annual effective dose equivalent (AEDE) for outdoor exposure of 0.18 mSv/yr was obtained at the road side of the market while the maximum value of 0.24 mSv/yr was obtained along the river bank. The calculated mean excess lifetime cancer risk (ELCR) was (0.74 $x10^{-3}$) as against the permissible limit of $0.29x10^{-3}$. The results of exposure to background ionizing radiation in Trailer park zone and Road side were in agreement with the standard limit of 0.013mRh^{-1}as recommended by the International Committee on Radiation Protection (ICRP) while in other areas the results were slightly above the ICRP recommended value. The computed absorbed doses (D) estimated were marginally higher than the safe value, however the average AEDE of the entire market was within safe value of 1.0$mSvy^{-1}$. The analysed dose to organs showed that the testes has the highest organ dose of 0.492 $mSvy^{-1}$ while the liver has the lowest organ dose of 0.276 $mSvy^{-1}$. In general, the results showed that the Swali market pose no serious radiological burden on the traders.

Keywords: Health indices; Investigation; Radiological risk; Swali market

INTRODUCTION
Market is usually an open space where people meet to buy and sell goods under the forces of demand and supply. The exchange of goods and services in market institution can operate as monopoly, oligopoly, and perfect competition. In monopoly market a seller may have control of supply and prices whereas in oligopoly market many of the sellers control prices. Perfect competition market encourages many buyers and sellers without price influence from any particular buyer or seller. Goods such as food items, clothing, domestic wares, industrial tools,

plastics et cetera are found in markets. Perfect competition market has sections for different goods and services. It can be individuals or small firms doing business transactions.

Swali market is the largest market in Bayelsa State. It is located in the capital city Yenagoa, near a popular sand dredging site, Swali Market Value (SMV). In Swali market all goods and services are available and by the side of the market is a jetty for access to riverine communities. Boat drivers and owners make brisk business conveying goods to and fro different destinations along the Atlantic shorelines. The riverine natives from fish towns such as Koluama, Akassa, Nembe, Brass, and Okpoama ferry their produce on engine boats, speed boats and canoes to off- load in the market, sell them and buy items for resale on a return trip. Swali market adds value to the economic wellbeing of the citizenry.

The removal of sand from their natural configuration and depositing them can also contribute to environmental problems by increasing the background ionizing radiation (BIR). Sand is used for all kinds of projects like land reclamations, the construction of artificial islands and coastline stabilization. Sand mining is a form of dredging which have economic and social benefits, but can also have environmental and health consequences. This is the formation of the bedrock of Swali market in Bayelsa State. Mining can also disrupts sediment supply and channel form, which can result in a deepening of the channel (incision) as well as sedimentation of habitats downstream, Ashraf et. al (2011). The environmental impact due to dredging stems from the suspension of sediment themselves and the release of pollutants from the disturbed sediment. These pollutants may contain radioactive materials in their natural geometry. Thus, dredging induced suspensions can perturb water quality and affect local biota, Dubois and Tower (1985). Human exposure to ionizing radiation from natural sources is an unending and unpreventable phenomenon on earth. Human exposure to natural radiation exceeds that from all man-made sources (including: medical, weapons testing and nuclear technologies) put together, Sadique and Agba (2011). The two main contributors to natural radiation exposures are: high-speed cosmic ray particles incident in the earth's atmosphere and the primordial radionuclides present in the earth's crust which are present everywhere, including the human body, Sadique and Agba (2011)**.** External exposure outdoors arises from terrestrial radionuclides present in trace levels in all soil types. Radiation emitted by these radionuclides within few centimetres of the topsoil reach the earth surface Farai and Vincent (2006). Radioactive materials, either particles or gases, might be transported crosswise over incredible separations by nearby and substantial scale air progress. The assessment of exposure to ionizing radiation is an imperative aim of radiation protection scientists and regulatory authorities. In public health management of radiation emergencies, one of the essential components of integrated assessment is to swiftly and precisely assess and classify the exposure UNSCEAR (2000).

Information of the background radiation level is of utmost significance Drek et. al. (2010). Farai and Vincent measured the

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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 0.45mSv/yr Farai and Vincent (2006). Sadiq and Agba measured the indoor and outdoor background radiation using an Inspector alert nuclear radiation meter and reported that the indoor readings ranged from 1.04 to 1.75mSv/yr while the outdoor readings ranged from 0.24 to 0.44mSv/yr Sadique and Agba (2011).

Swali market has not been previously assessed for ionizing radiation risk hence investigation of radiological health indices was carried out through set out objectives which included but not limited to measurement of BIR, computation of hazard parameters, and comparison of results with world best known standards.

MATERIALS AND METHODS

Study Area

The study area is Swali market Yenagoa, it lies within latitude $4^0$55'0"N and longitude $6^0$16'60"E. Swali market is located in Yenagoa local government area of Bayelsa State Nigeria. Bayelsa State is in the core Niger Delta region of Nigeria with abundant deposit of hydrocarbon and natural Gas. Niger Delta is also blessed with other mineral resources such as Fine Sand and Clay (used in pottery and porcelain production), Arjayay (2018). Swali is a populated place in Bayelsa State with large traffic of human movement Nigeria. Swali market is an ever busy market which uniquely sits on the bank of Yenagoa River in the Bayelsa State capital. The market is one where residents can obtain fresh fish, aquatic produce among other things for their domestic use. Figure 1, shows the Swali market, the study area.

Figure 1: The Study Area.

Field Measurement

The *in situ* measurements of the terrestrial radiation level of Swali market areas were done directly in an undisturbed manner, using a well calibrated radiation monitor, Digilert-200 and Radalert-100 nuclear radiation monitoring meter (S.E. International Incorporation, Summer Town, USA). The radiation monitoring meters contain a Geiger-Muller tube capable of detecting alpha, beta, gamma and X-rays within the temperature range of 10℃ and 50℃. The Geiger-muller tube generates a pulse current each time radiation passes through the tube and causes ionization Ononugbo et. al (2016). Each ionized air particle was electronically detected and registered as a count. The meter has an accuracy of ±15%. The measurements were carried out by positioning the radiation meter at the targeted sample located at varying distance in the market established by Geographical Positioning System (GPS). Measurements were taken within 10:00 and 16:00 hours since the meter has a peak response to environmental radiation within these hours, then the background radiation level was recorded. In order to ensure quality assurance the provisions taken include: Two measuring instrument were deplored to field and standardization of the measuring instrument 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.

Data analysis/conversion:

The generated data were converted to absorbed dose rate nGy h^{-1} using the relation for the external exposure rate by NCRP (1999).

$$1\mu R/h = 8.7\ nGy/h \quad (1)$$

The results were presented in form of mean and standard deviation while the bar chart illustrations were drawn to determine the significant relationships between the radiations at different sample points.

RESULTS AND DISCUSSIONS

Results

The results for the *in-situ* measurement of terrestrial radiation level and the calculated values for gamma dose, Annual Effective Dose Equivalent (AEDE) and Excess Lifetime Cancer Risk (ELCR) of the Swali market areas are presented in Tables 1-7 while Table 8 presents the summary of computed radiological health hazard indices or parameters. Figures 2, 3, and 4 show the comparison of BIR, Absorbed dose, mean ELCR with their corresponding recommended values, while Figure 5 shows the Dose to different organ/tissue.

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Table 1: The mean radiation exposure rate and estimated radiation risk parameters at the Market Entrance/Junction

SAMPLE POINT	Geographical Position	AVERAGE BIR (mR/hr)	Absorbed dose rate (nGy/hr)	Annual effective dose (mSv/yr)	ELCR (10^{-3})
SW 1	$4^0$55’060’’ $6^0$16’008’’	0.022±0.003	191.40	0.29	0.81
SW2	$4^0$55’055’’ $6^0$16’002’’	0.039±0.002	339.30	0.52	1.82
SW3	$4^0$55’053’’ $6^0$16’59.6’’	0.009±0.001	78.30	0.12	0.42
SW4	$4^0$55’04.8’’ $6^0$16’59.1’’	0.016±0.002	139.20	0.21	0.75
SW5	$4^0$55’04.7’’ $6^0$16’58.5’’	0.007±0.001	60.90	0.09	0.33
SW6	$4^0$55’04.5’’ $6^0$16’58.0’’	0.009±0.001	78.30	0.12	0.42
MEAN		**0.017±0.005**	**147.90**	**0.23**	**0.76**

Table 2: The mean radiation exposure rate and estimated radiation risk parameters at Centre of the market

SAMPLE POINT	Geographical Position	AVERAGE BIR (mR/hr)	Absorbed dose rate (nGy/hr)	Annual effective dose (mSv/yr)	ELCR (10-3)
SW7	$4^0$55’04.2’’ $6^0$16’57.4’’	0.024±0.001	208.80	0.32	1.12
SW8	$4^0$55’03.8’’ $6^0$16’56.8’’	0.019±0.003	165.30	0.25	0.89
SW9	$4^0$55’03.6’’ $6^0$16’56.6’’	0.016±0.001	139.20	0.21	0.75
SW10	$4^0$55’03.3’’ $6^0$16’55.6’’	0.011±0.001	95.70	0.15	0.51
SW11	$4^0$55’03.0’’ $6^0$16’55.0’’	0.012±0.002	104.40	0.16	0.56
MEAN		**0.016±0.005**	**142.68**	**0.22**	**0.77**

Table 3: The mean radiation exposure rate and estimated radiation risk parameters at Exit Area

SAMPLE POINT	Geographical Position	AVERAGE BIR (mR/hr)	Absorbed dose rate (nGy/hr)	Annual effective dose (mSv/yr)	ELCR (10-3)
SW12	4^{0}55’03.0’’ 6^{0}16’54.7"	0.021±0.002	182.70	0.28	0.98
SW13	4^{0}55’03.6’’ 6^{0}16’54.1’’	0.010±0.001	87.00	0.13	0.47
SW14	4^{0}55’03.7’ 6^{0}16’54.9’'	0.019±0.001	165.30	0.25	0.89
SW15	4^{0}55’03.9" 6^{0}16’55.4’'	0.016±0.001	139.20	0.21	0.75
MEAN		**0.017±0.005**	**143.55**	**0.22**	**0.77**

Table 4: The mean radiation exposure rate and estimated radiation risk parameters Along River bank

SAMPLE POINT	Geographical Position	AVERAGE BIR (mR/hr)	Absorbed dose rate (nGy/hr)	Annual effective dose (mSv/yr)	ELCR (10-3)
SW16	4^{0}55’04.2" 6^{0}16’56.1"	0.016±0.002	139.20	0.21	0.75
SW17	4^{0}55’57.7" 6^{0}16’56.0"	0.015±0.001	130.50	0.20	0.70
SW18	4^{0}55’56.1" 6^{0}16’57.1"	0.022±0.002	191.40	0.29	1.03
SW19	4^{0}55’57.4" 6^{0}16’57.3"	0.020±0.002	174.00	0.27	0.93
MEAN		**0.018±0.003**	**158.78**	**0.24**	**0.85**

Table 5: The mean radiation exposure rate and estimated radiation risk parameters at Slaughter and Periwinkle Dump Area

SAMPLE POINT	Geographical Position	AVERAGE BIR (mR/hr)	Absorbed dose rate (nGy/hr)	Annual effective dose (mSv/yr)	ELCR (10-3)
SW20	4^{0}55’55.2" 6^{0}16’59.4"	0.016±0.001	139.20	0.21	0.75
SW21	4^{0}55’52.3" 6^{0}16’59.4"	0.016±0.002	139.20	0.21	0.75

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SW22	$4^0$55'52.6" $6^0$16'59.1"	0.021±0.001	182.70	0.28	0.98
SW23	$4^0$55'53.3" $6^0$16'00.1"	0.011±0.001	95.70	0.15	0.51
MEAN		**0.016±0.004**	**139.20**	**0.21**	**0.75**

Table 6: The mean radiation exposure rate and estimated radiation risk parameters at Trailer Park area.

SAMPLE POINT	Geographical Position	AVERAGE BIR (mR/hr)	Absorbed dose rate (nGy/hr)	Annual effective dose (mSv/yr)	ELCR (10-3)
SW24	$4^0$55'54.3" $6^0$16'59.6"	0.024±0.001	208.80	0.32	1.12
SW25	$4^0$55'55.6" $6^0$16'59.7"	0.011±0.001	95.70	0.15	0.51
SW26	$4^0$55'55.6" $6^0$16'00.2"	0.017±0.003	147.90	0.23	0.79
SW27	$4^0$55'57.9" $6^0$16'59.3"	0.009±0.001	78.30	0.12	0.42
MEAN		**0.015±0.007**	**132.68**	**0.20**	**0.71**

Table 7: The mean radiation exposure rate and estimated radiation risk parameters at Road side Area

SAMPLE POINT	Geographical Position	AVERAGE BIR (mR/hr)	Absorbed dose rate (nGy/hr)	Annual effective dose (mSv/yr)	ELCR (10-3)
SW28	$4^0$55'58.4" $6^0$16'59.7"	0.018±0.001	156.60	0.24	0.84
SW29	$4^0$55'59.2" $6^0$16'01.3"	0.010±0.002	87.00	0.13	0.47
SW30	$4^0$55'59.4" $6^0$16'02.9"	0.011±0.003	95.70	0.15	0.51
SW31	$4^0$55'01.1" $6^0$16'03.3"	0.018±0.002	156.60	0.24	0.84
SW32	$4^0$55'01.5" $6^0$16'01.8"	0.018±0.001	156.60	0.24	0.84
SW33	$4^0$55'03.6" $6^0$16'01.0"	0.007±0.001	60.90	0.09	0.33
MEAN		**0.014±0.005**	**118.90**	**0.18**	**0.64**

Table 8: Summary of Radiation Exposure rate and Computed Hadiological health Indices of Swali market.

SAMPLE POINT	AVERAGE BIR (mR/hr)	Absorbed dose rate (nGy/hr)	Annual effective dose (mSv/yr)	ELCR (10^{-3})
ENTRY POINTS/MARKET JUNCTIONS	0.017±0.005	147.90	0.23	0.76
CENTER OF THE MARKET	0.016±0.005	142.68	0.22	0.77
EXIT AREAS	0.017±0.005	143.55	0.22	0.77
ALONG RIVER BANKS	0.018±0.003	158.78	0.24	0.85
SLAUGHTER AND PERIWINKLE DUMP AREAS	0.016±0.004	139.20	0.21	0.75
TRAILER PARK AREA	0.015±0.007	132.68	0.20	0.71
ROAD SIDE AREAS	0.014±0.005	118.90	0.18	0.64
MEAN	**0.016±0.006**	**139.72**	**0.21**	**0.74**

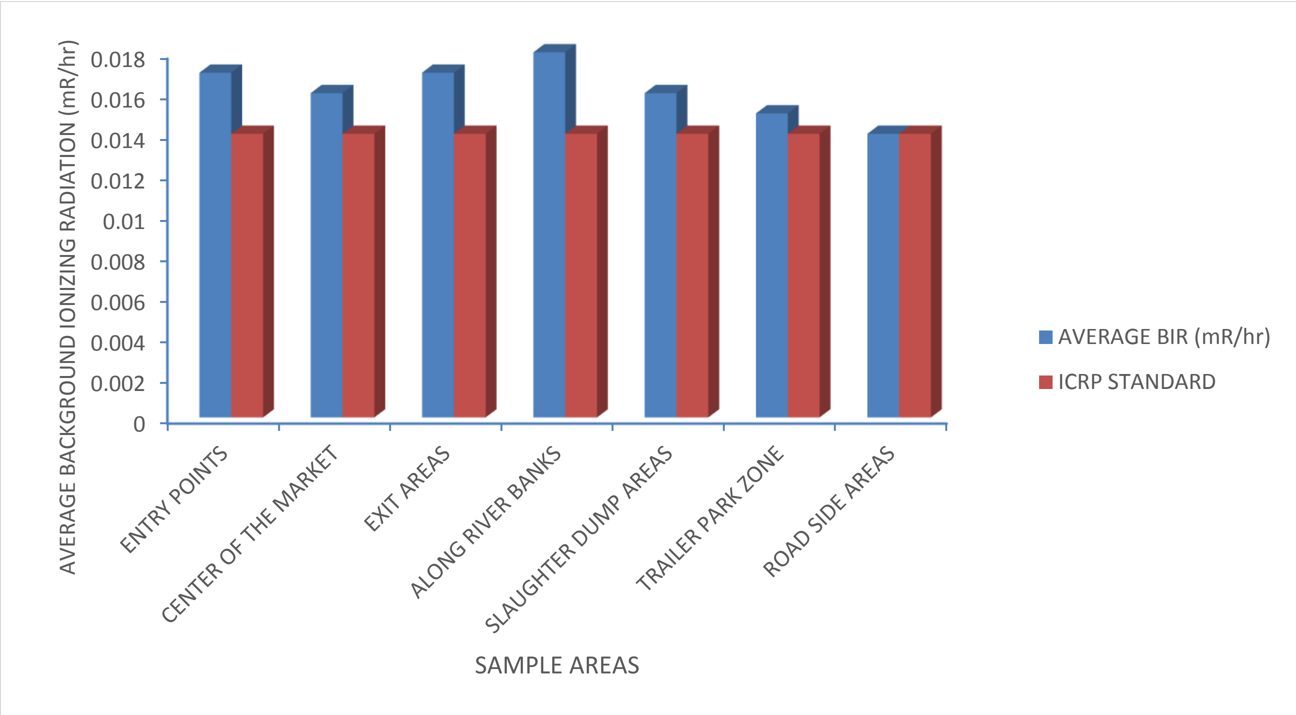

Fig. 2. Comparison of measured BIR levels with standard

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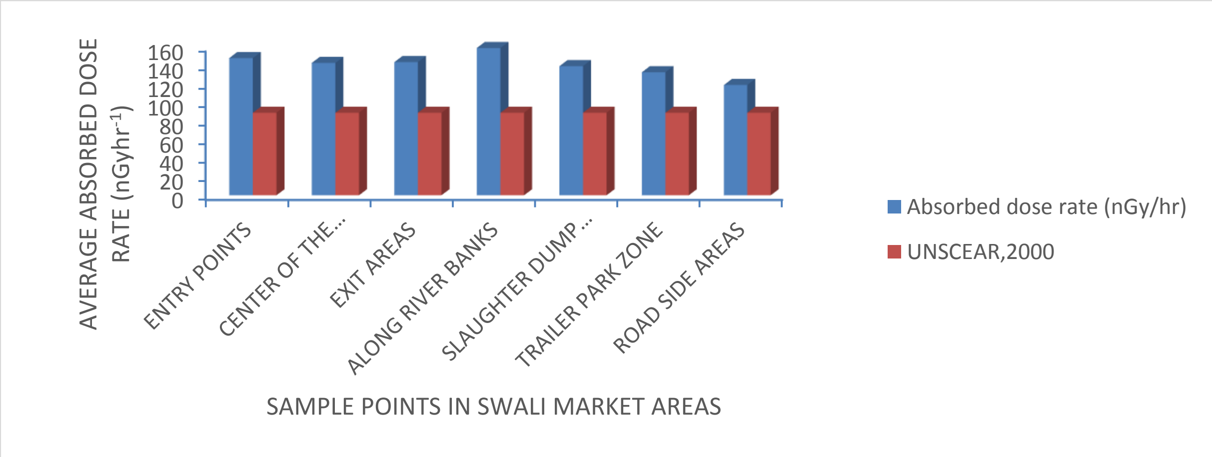

Fig. 3. Comparison of average absorbed dose rate of Swali Market areas

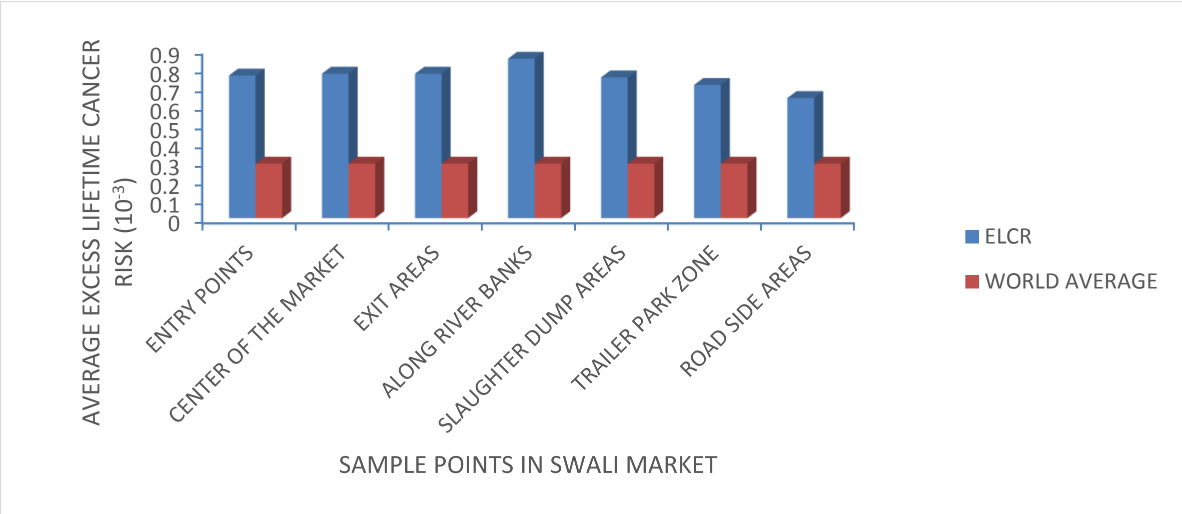

Fig. 4. Comparison of mean ELCR of Swali market area with World safe limit value

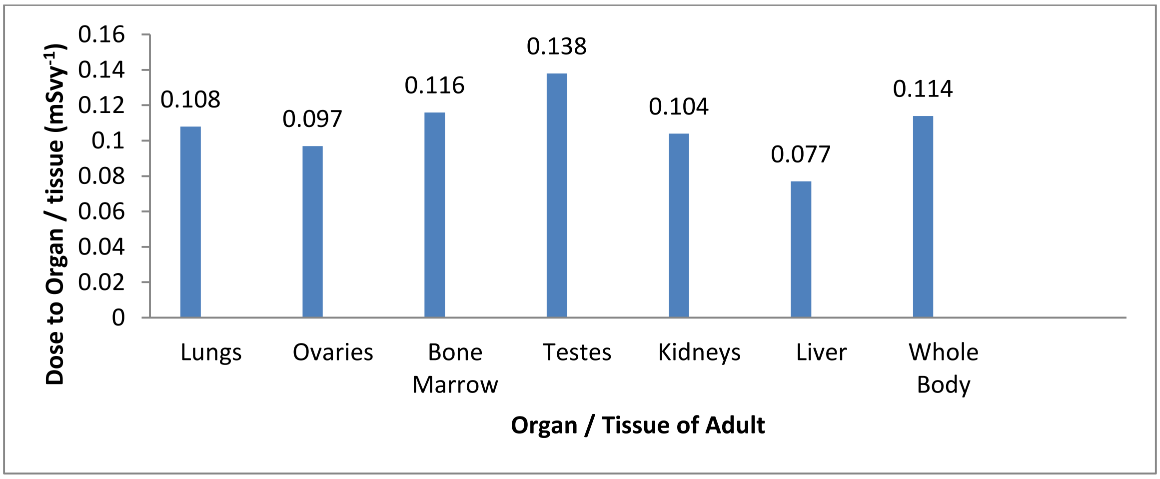

Fig. 5. Annual Effective dose rate ($mSvy^{-1}$) to different organs/tissues

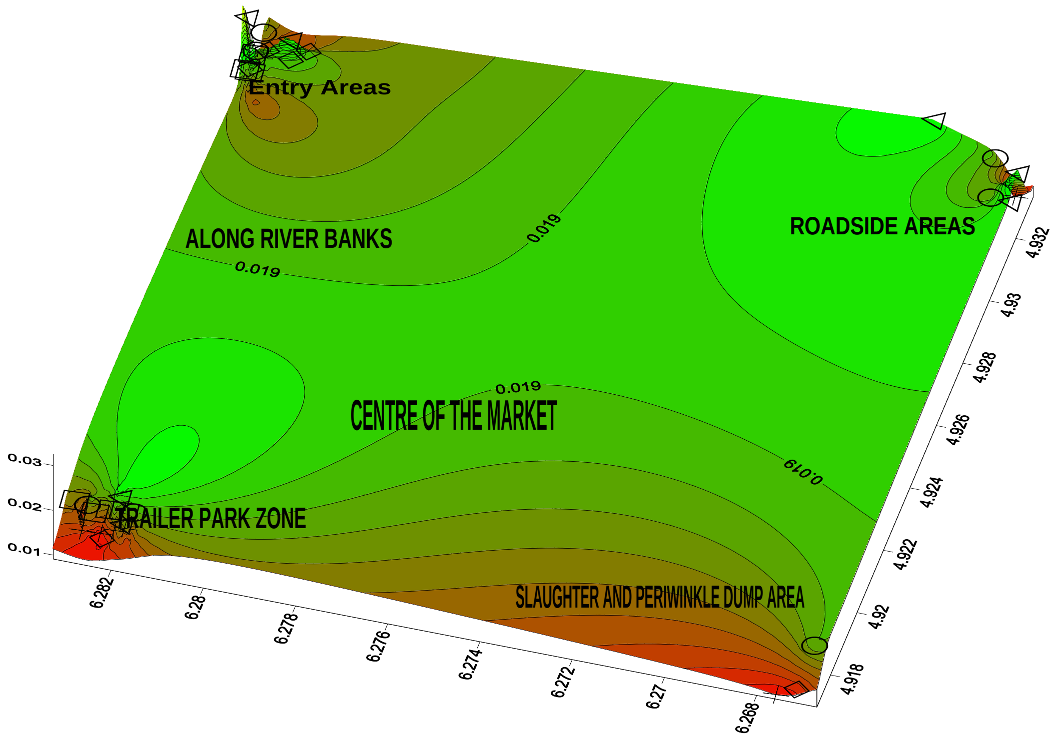

Figure 6. Radiation Contour-post map of Swali Market

Annual Effective Dose Equivalent (AEDE)

The AEDE can give a clue on indication of radiological contamination in an outdoor environment which may result to inhalation of high level of radon gas emitted and its progeny from the market areas which can lead to lung cancer from accumulated doses, Ademola and Onyema (2014). Measured absorbed gamma dose rates were used to calculate the annual effective dose equivalent (AEDE) received by individuals within and around the market sites. In calculating AEDE, dose conversion factor of 0.7 Sv/Gy and the occupancy factor for outdoor of 0.25 (6 hours out of 24 hours) was used. The occupancy factor for outdoor was calculated based upon interviewing the peoples of the market area. People of the market study area spend almost 6 hours outdoor due to the nature of their routine. The annual effective dose equation was estimated using the following relation UNSCEAR (2000).

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

Excess Life Cancer Risk (ELCR)

The probabilities of contacting cancer by the oil workers and residents of the study area who will spend all their life time in this environment can be estimated using the Excess Lifetime Cancer Risk (ELCR) even in the absence of outbreak radioactive components. This study is based on the traditional worldwide radiation protection standards for late (stochastic) effects which are based on the LNT hypothesis, Stewart et. al. (2017).

The annual effective dose calculated was used to estimate the Excess Lifetime

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Cancer Risk (ELCR) is calculated using equation (3).

$$ELCR = AEDE \times Average\ duration\ of\ life \times Risk\ factor\ Rf \quad (3)$$

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 Mishra (2017).

Effective Dose Rate {D_{organ} ($mSvy^{-1}$)} to different Organs/ Tissues

The effective dose rate to an individual organ can be calculated using the relations;

$$D_{organ}(mSvy^{-1}) = Occupancy\ factor, O \times AEDE \times Conversion\ factor, F,$$ Zaid et al.(2010), ICRP (1996).

AEDE is the annual effective dose, the occupancy factor, O is 0.8 and conversion factor, f for organ dose from ingestion is obtained from ICRP 1996.

Discussion

BIR levels

The terrestrial radiation level with the uncertainty measurement and radiation parameters of the Swali market sites (Entry points/market junctions, Centre of the market, Exit areas, Along River banks, Slaughter and Periwinkle dump areas, Trailer park area and Road side areas) and its environs in Bayelsa State was determined and results presented in Tables 1 to 4. The summary of the radiation levels and the respective radiation parameters are presented in Table 5. The range of average radiation exposure levels were 0.009±0.001 – 0.022±0.003 mRh^{-1}(Entry points/market junctions), 0.011±0.001 – 0.024±0.001 mRh^{-1}(Centre of the market), 0.010±0.001 – 0.021±0.002 mRh^{-1}(Exit areas), 0.015±0.001 – 0.022±0.002 mRh^{-1}(Along River banks), 0.011±0.001 – 0.021±0.001 mRh^{-1}(Slaughter and Periwinkle dump areas), 0.009±0.001 – 0.024±0.001 mRh^{-1}(Trailer park zone) and 0.007±0.001 – 0.018±0.001 mRh^{-1}(Road side areas). The sparsely high background radiation exposure in the study areas could be attributed to dredging activities which constituted the major soil mineral constituent deposited to form the foundation of these areas over time. The values recorded here are higher than the ICRP standard for normal background radiation level. The mean exposure rate of different sections of Swali market areas were found to be higher than the value obtained in Akwa-Ibom state (0.007-0.015 mR/hr), Akpabio et. al. (2005). Dredged soil particles could have contributed to the high value of BIR in the market areas as the residue of the extraction process may contain the radioactive minerals. The distribution of the BIR levels of the studied area was represented by the contour plot of Figure 6 using Surfer 8 a contouring and 3D surface mapping program that runs under Microsoft Windows. Surfer8 can transform ones data into knowledge by easily creating a multitude of map types to visualize the data. This is used to generate 3D surface maps of the location with respect to average radiation absorbed dose rate, with the abscissa (X-axis) representing Eastings, Northings represented by the ordinate (Y-axis) and the average absorbed dose rate represented by the Z-axis. The relative spacing of the contour lines indicates the relative slope of the surface (Figure 6).

Some part of the market has a clustered sparsely distribution of BIR and some densely distributed.

Absorbed Dose rate

The result of the radiation absorbed dose rates for the Swali market sites are presented in Table 2. The mean absorbed dose of radiation estimated from the BIR levels in the Swali market sites ranges from 118.90 (Rivers side areas) - 158.78 (Along river bank) $nGyh^{-1}$. The values reported at Entry point, market centre and Exit Areas of Swali market areas were higher than those reported for slaughter and periwinkle dumpsite area and Trailer park zone of Swali market sites. The mean radiation dose rate measured were respectively higher than the value of 54.6 $nGyh^{-1}$previously reported in Delta State by Arogunjo et. al. (2004) and were also higher than the value of 20.37 $nGyh^{-1}$ previously reported in Akwa-Ibom covering Eastern Obolo, Ibeno and Ikot Abasi, Akpabio et. al. (2005). The measured outdoor gamma dose rates are also comparable to the range of values of 78.3-135.7 $nGyh^{-1}$ reported in Turkey by Eree et. al. (2006), and higher than the value reported in Poonch district (102 $nGyh^{-1}$) Rafique et. al. (2013). The energy deposited on individual as a result of ionizing radiation exposure in Swali market areas are not at alarming state. The absorbed doses estimated are slightly less than the world permissible value of 89.0 $nGyh^{-1}$ as shown in Fig. 3. The high absorbed dose rate in river banks of Swali market areas could be due to impact of the dredging activities and sedimentation which have disrupted the system over time and have enhanced the release of pollutants from the disbursed sediment. The high absorbed dose rate in trailer park zone could be due to impact of the oil spills or leakage from excavation machinery and transportation vehicles over time.

Annual Effective Dose Equivalent (AEDE)

The Annual Effective Dose Equivalent for Swali market areas ranges from 0.18 (road side area) to 0.24 (River banks) $mSvy^{-1}$ with a mean value of 0.21 $mSvy^{-1}$. The mean annual effective dose equivalent for areas in Swali market at the Entry points (0.23 $mSvy^{-1}$), Centre of the market (0.22 $mSvy^{-1}$), Exit areas (0.22 $mSvy^{-1}$), Along River banks (0.24 $mSvy^{-1}$), Slaughter and Periwinkle dumpsite areas (0.21 $mSvy^{-1}$), Trailer park area (0.20 $mSvy^{-1}$) and Road side areas (0.18 $mSvy^{-1}$) was estimated respectively. The annual effective dose estimated around the road side areas are lower than the value obtained in Akwa-Ibom, Akpabio et. al. (2005). The annual effective doses in the Swali market areas were lower than world average of 0.48 $mSvy^{-1}$. This implies the marketers at Swali market are not at risk and the level of doses obtained in these areas might not be capable of exerting some acute and long-term adverse health effects.

Excess Lifetime Cancer Risk (ELCR)

The value of excess lifetime cancer risk (ELCR) obtained in Swali market areas ranges from Road side areas (0.64×10^{-3}) to along River Bank (0.85×10^{-3}) with an average of 0.74×10^{-3}. Excess lifetime cancer risks estimated for the entire studied market sites were higher than average world standard of 0.29×10^{-3} as shown in Fig. 4.

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Effective Dose Rate to Organs/ Tissue

The calculated effective dose rates delivered to the different organs such as lungs, Ovaries, Bone marrow, testes, kidneys, liver and whole body are presented in Figure 5 with numerical values of 0.108, 0.097, 0.116, 0.138, 0.104, 0.077, 0.114 $mSvy^{-1}$respectively. The model of the annual effective dose to organs estimated the amount of radiation intake by a person which enters and accumulates on various body organs and tissues, Agbalagba (2017). Seven organs and tissues were observed and the outcome shows that the testes received the highest dose of 0.138 $mSvy^{-1}$ while the lowest dose of 0.077 $mSvy^{-1}$ was found in the liver as shown in Figure 5. These result show that the calculated doses to the different organs studied are all below the international tolerable limits on dose to body organs of 1.0 $mSvy^{-1}$. The relatively higher dose to the testes and low dose intake to the liver may be due to different absorption rate and conversion factors, Agbalagba et. al. (2012). This result shows that exposure to BIR levels in the Swali market areas of Bayelsa contributes insignificant radiation dose to these organs in adult.

CONCLUSION

Investigation of Radiological Health Indices in Swali Market was successfully carried out. The results showed slightly elevated background ionizing radiation, high estimated absorbed dose, moderate annual equivalent dose, and slightly high excess life time cancer risk. The values of these indices were not found to be at alert levels therefore the market is safe and therefore pose no serious environmental radiological burden on the traders. However, periodic radiation monitoring is recommended should there be sudden BIR elevation as a result of certain radioactive waste generated from the Swali market.

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