ASSESSMENT OF ENVIROMENTAL RADIATION SOURCE ^{222}Rn AND IT'S HEALTH CONSEQUENCES ON THE POPULACE IN OSHIMILI NORTH PART OF DELTA STATE, NIGERIA.

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Abstract

The essence of life on earth is dependent on radiation photochemical transformation for sustainable life activities and the main natural environmental radiation sources on earth are radon and atmospheric radiation. Exposure to radon gas can have negative health effects through inhaling smokes from cigarettes and smokes from industries which can cause lung cancer over time 2014 edition of the international basic safety standards (I.B.S.S) was adopted. This study presents environmental radiation monitoring; the radon within the environment is measured using a professional radon monitoring instrument (Alpha Guard PQ 2000 PRO) and a geographical positioning system (GPS –Gaiman GPS map 76s). The recorded mean radon concentration varied from 10.8±4.80 Bq/m^{3}to 21.90 ±15.6Bq/m^3 ,15.6Bq/m^3 is high due to the uncertainty to few radon counts while taking readings) 21.90Bq/m^3 which is within the WHO accepted range(100Bq/m^3) the average values of the estimated radiation risk parameters which includes radon concentration, radon exhalation rates and excess lifetime cancer risk due to exposure from their progeny are 4.2Bq/m^3 to 8.4Bq/m^3, 1.22x10^{-3}mwl to 2.5x10^{-3}mwl, 0.003x10^{-3}wml/y to 0.08x10^{-3}wml/y respectively. The calculated radon factors fall within the WHO recommended limits. The study area is termed safe and poses no threat to human health.

Keywords: Radon gas, Radiation, Absorbed dose, Photochemical, Alpha guard PQ.

Introduction

Delta state Nigeria is an oil-rich region in the Niger Delta area facing numerous industrial and environmental challenges (EPA, 2019) some of the concerns includes oil pollution as a result of oil extraction have led to widespread contamination of land water and air affecting local ecosystem and communities at large, Environmental degradation includes deforestation soil erosion and flooding are common issues (E. Deborah et al,.2020). Background Radiation is produced by naturally occurring radioactive minerals in the soil, water, and earth. Some of these naturally occurring radioactive minerals are even found in the human body. It is also influenced by cosmic radiation from space, most times our habitants are engrossed by environmental radiation that yields in radiation (Salih.,2019). Only a tiny portion of background radiation originates from artificial elements; the bulk comes from minerals that occur naturally. Some of these naturally occurring radioactive minerals are even found in the human body through the air we breathe, the food and drink we ingest, more so our own bodies contain radiation from both natural and artificial sources.

Table 1: Natural and Artificial radiation sources. (RIFE, 2022).

Natural radiation sources	%
Radon	51%
Gamma rays from radioactive materials in the earth	14%
Naturally 40 potassium in food	12%
Cosmic radiation	10%
Artificial radiation sources	**%**
X-rays / radioactive material used to diagnose disease	12%
Radioactive discharges, occupational exposure, fallout from historical nuclear testing and nuclear accidents, and miscellaneous	

The radiation dose measure units of radiation per year from all sources 2.4 mSv/year. Every day we are all subjected to a certain amount of radiation. Radon, Radium and Uranium are the 3 major sources of environmental radiation. The major environmental radiation source is Radon gas which contributes nearly 2/3 of our natural background radiation, and it appears that every human has radiation present in their bodies mainly radioactive elements like potassium K^{40} and carbon C^{14}. Both naturally occurring and artificially created radiation sources contribute to environmental radiation in our surroundings (UNSCEAR,.2020). Environmental radiation is frequently referred to as "background radiation." Iowans are exposed to radiation from 60 milligram of man-made sources to 300 milligrams of natural radiation per year on average (EPA,.2022). Radiation is a frequent and useful tool in industry, research, and medicine today. In medicine, it is used in large dosages to treat conditions like cancer and to identify ailments. To prolong the shelf life of fresh produce and eradicate dangerous micro-organisms from food, strong radiation dosages are also employed.

Researchers are working hard to assess the environmental radioactive activities on earth surface like soil, water and foods which are constantly in contact with humans (Avwiri et al, 2005). It is best we know its effects on lives and estimate the deposition of these radioactive components with its natural background impacts on humans. Natural activity may have an impact on the concentration and position of some natural isotopes, especially Helium (^{3}H) and Carbon (^{14}C). (Wikipedia.,2009), (fig 1).

Fig 1: Schematic diagram of Environmental radiation sources (iastate, 1995)

Among other naturally occurring radioactive elements like helium ^{3}H, potassium ^{40}K and Carbon ^{14}C represents the group of NORM they are the most essential elements that exists within our environments and we are all exposed to this radiation on daily basis through our surroundings (EPA,.2011) , Ionizing radiation is produced by unstable atoms we have stable and unstable atom, unstable atoms has excess energy and mass (HERO,. 2024), Radiation can also be produced by high –voltage devices (e.g. x-ray machines and phones). Other sources of environmental radiation that play a role in our various environments are Anthropogenic Sources under artificial sources of environmental radiation**;** Activities such as oil drilling and mining can potentially increase radiation levels. Waste Management: Improper disposal of radioactive waste can lead to environmental contamination. Radiation pollution from nuclear waste disposals poses yet another significant risk to environment and human health with limited solutions provided like lack of standardized radiation monitoring protocols ,data sharing hinders international collaboration and effective response to environmental radiation threats , the impact of environmental radiation on human (IAEA ,2020) immune system is not well emphasized making it challenging to develop effective treatments for radiation related illness caused by the exposure of these high rate of radioactive elements like Radon etc. (Chikkaraddy R. et al 2016) .The purpose of this research is to assess and create awareness about Radon and its effects on human health and how to stay prevented from getting exposed to them on high rate as it causes lung cancer. Radon is the largest source of radiation in environment produced from decay of uranium and thorium (Mokobia,.2022). Radon is a natural radioactive gas formed by the breakdown of uranium gas that results as a source of this tasteless, odorless and invisible gas humans gets expose to it through breathing such as cigarette smokers , smokes from burning items the gas inhaled in the process that causes lung cancer, every year thousands of people dies from lungs cancer , Radon gas particularly in area with high natural uranium content in **s**oil and rocks can be found in water (IAEA,.2014**),** Radon exits from the ground into the air where it decays and produces further radioactive particles deposited on the cell airways can cause DNA damage or lung cancer ,outdoors radon quickly neutralizes to very low concentrations and is generally not a problem. The average outdoor radon level (*1*) varies from $5Bq/m^3$ to $15Bq/m^{3.}$ However, radon concentrations are higher indoors and in areas with minimal ventilation, with highest places like caves and water treatment facilities, Fig1.2 below illustrates how Radon affects building

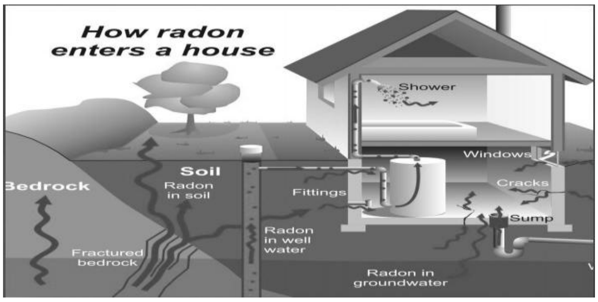


Fig 1.2 How radon gas affects the lungs David Daniels,.2019)

In buildings such as homes, schools , offices, radon level can vary substantially from $10Bq/m^3$ to more than $10{,}000Bq/m^3$ given the properties of radon occupants of such buildings, it is important that we apply preventive measures that will help us stay free of its radiological health implications by implementing a national radon programs aimed at reducing both the overall population risk and the individual risk for people living with high radon concentrations in the northern part of Delta state Nigeria (WHO,.2009), another way of eradicating the environmental radiation health risks are by developing radon measurement protocols to help ensure quality consistency in radon testing and establishing a national annual average residential radon concentration reference level of $100Bq/m^3$ with radon prevention building codes to help reduce radon levels in buildings under construction and radon programs to ensure that the levels are below national reference levels of $300Bqm^{-3}$.

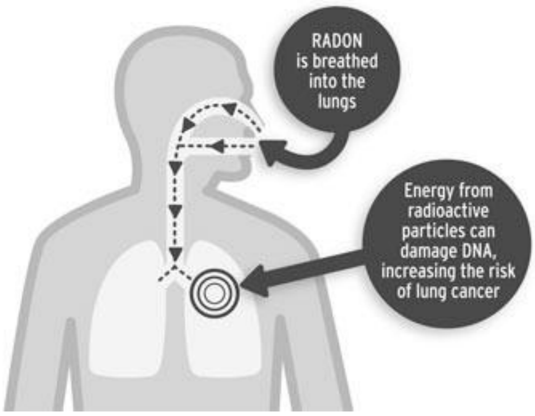


Fig 1.3 How radon gas affects the lungs (ICRP,.2019)

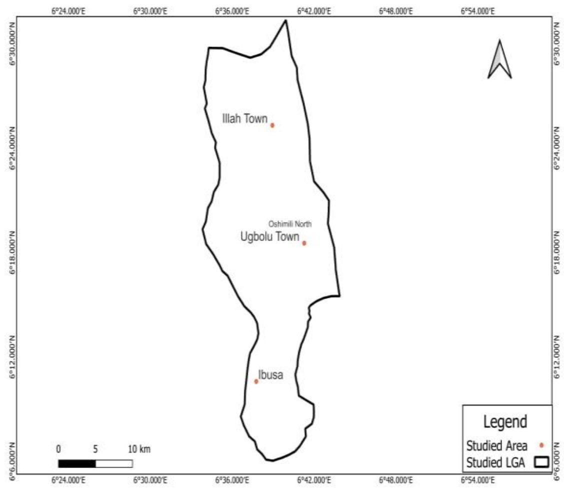
Radon gas decays into energetic particles emitted from unstable atoms which gets trapped in lungs when inhaled. As they break down further, these particles release small bursts of energy that lead to lung cancer. As life progresses, energy from particles can damage DNA or alter a genetic trait (ICRP,.2019). The lungs need to release the energy inhaled from the surroundings through exhalation and food processing metabolism in the body systems.

Significance of Study

This study will serve to advise the public and world at large on the radiological hazards of uncontrolled environmental radiation effects sources like Radon, contaminated soil and water, nuclear waste disposals and accidents that poses a significant risk.

Area of study

Delta north (fig 2.0) comprises of Oshimili North and South , Aniocha north and south , ukwuani, ika north and south and the rest of it but this research is focused on oshimili north local government area of delta state with it's headquarters in Akwukwu-Igbo and comprises of other towns like Ibusa, Okpanam, Ugbolu, Ebu, illah ,Ukala and Ugbolu etc . The estimated total population of Oshimili North LGA is put at 304,800 inhabitants with the area mostly inhabited by members of the Anioma ethnic affiliation (ManPower, 2022). Oshimili North is one of twenty-five local government areas that made up Delta state South-South geo-political region of Nigeria, and it was created 1997. These towns precisely are important town in Oshimili north and are the commercial nerve centre, the area is partly river line with large sandy soil for construction purposes with few of mangrove forests and has a land area approximately 1084 km^2 which covers the most geographical area in Oshimili North and culture with latitude of 6^0 22'58" N and longitude 6^0, 37' 28" E for their DMS coordinates lat(long(dec) 6.38265, 6.62431), climate type tropical savannah wet which makes the soil more conducive for conservation ,construction and agriculture.



. Fig 2.0. The map of Oshimili North of Delta State.

Gas flaring is the continuous burning of natural gas releases toxic chemicals contributing to air pollution and climate change, Waste management is adequate disposal of industrial and domestic waste leads to environmental hazards also the aspect of Health impacts faces increased risks of cancer, respiratory problems and other health issues due to environmental pollution (NCBI, 2019), Environmental radiation can have significant health consequences, and this is particularly relevant in areas where radiation exposure is higher due to natural or anthropogenic sources. In this study, mostly likely health hazards are Lung Cancer and tuberculosis.

Materials and Methods

The following are the different materials used

Alpha Guard PQ 2000 PRO

Geographical positioning system GPS – Garmin GPS map 76s

Alpha guard set-up

The Alpha Guard is the main component of a professional portable system for continuously measuring the concentration of radon ^{222}Rn and radon progeny in Air, as well as specific climate variables. Depending on the model and configuration, Alpha guard allows users to distinguish between radon and thoron measurements and simultaneously record both the radon progeny concentration and the gamma dose rate .The systems measurement operations controlled by the real-time clock ,store the results in a ring memory (first-in, first-out) to ensure that the most recent 60,000 data sets are always available and downloadable to a computer via USB RS-232 or Bluetooth interface o,even with continuous operation .Alpha Guard can operate independently or with an external power source and features an integrated rechargeable battery that enables up to 10days of independent operation.(Bertin ,.2019), (fig.3) Schematic diagram of Alpha guard pro 2000 set-up for radon detector.

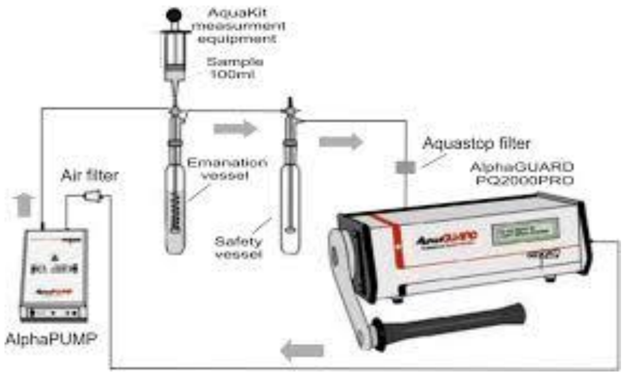


Fig.3. Schematic diagram of Alpha guard pro 2000 set-up for Radon detector.

For measuring the radon emanation from materials, A wide range of accessories for remote and stationary monitoring allows customized solutions for online alarm monitoring in remote areas and the realization of rugged monitoring stations, this instrument is used to ascertain the quantity of radon gas in that study area.

The (GPS)- Geographical positioning system

Geographical positioning system encompasses a global network of satellites and receiving apparatuses, which collectively determines the precise location of objects on the earth's surface. High-end GPS receivers can pinpoint their position with an astonishing accuracy of just one centimeter (roughly 0.4inches). providing location data in the form of latitude, longitude and altitude, (Bender P.L et al.,1985)

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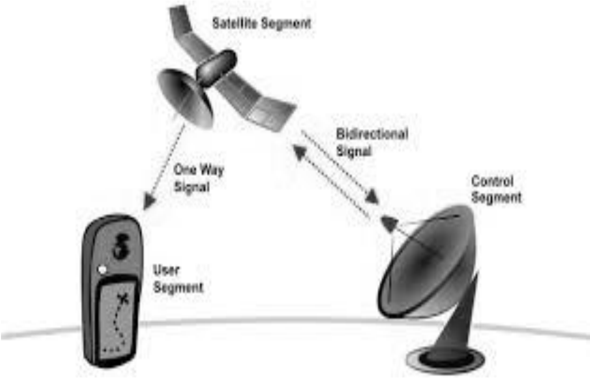


Fig 3.1. Represents the diagram of the geographical positioning system (Bender P.L et al.,1985).

Radiological Computations

Research reveals how radon progeny's concentration is commonly represented in form of working levels (WL) ,one WL is said to be expressed as any combination of short lived radon daughters ion 1litre of air that results in the ultimate release of 1.3×10^5 million electron volts of alpha energy ,The concentration of short-lived daughters increases a particular volume of radon given out to an equilibrium reached point at a particular unit (pCi/L) of radon gives rise to0.01uWL definitely. Studies show that these conditions do not hold in general: Considering our homes, the equilibrium fraction is approximately 40% which means there will be0.004 WL of progeny 7 for each pCi/L of radon in air as reported by National Academy Press in US (NAP, 1999). Building materials in use in our homes produce some radon as well.

Radon exposures are simplified and measured in working level months (WLM), Is possible to conclude that the exposure is proportional to concentration (wl) and time ,1 wl for 170 hours being defined as 1 wlm. In the same procedure residential exposures are expressed in pCi/L, research revealed that the fraction of time spent indoors is 70%. It follows that an indoor radon concentration of 1 pCi/L would on average result in an exposure of 0.144 wlm/y = (1 pCi/L) [(0.7) (0.004) wl/ (pCi/L)] (51.6 wlm/wl^{-y}). Hencecalculation expressions below, Activity concentration of ^{222}Rn is as small as $1Bqm^{-3}$ may be measured with some these dosimeters, radon levels in homes vary greatly from region to region and is detected as follows

Radon concentration, Radon Dose = Radon level x Time of exposure ……….. ………………………….….. (1)

$$WL = \frac{ER\times Cr\times PCi/L}{100} \quad \text{…………………………….……. (2)}$$

Radon concentration is calculated

$$pCi/L = \frac{WL\ X\ 100}{ER} \quad \text{…………………………………..(3)}$$

Dose Coefficient: calculating the dose from inhaling radon ^{222}Rn involves multiplying the average radon level (e.g. in Bq/m^3) by the time spent and the right dose coefficient (ICRP,.2019),

Efficient dose = radon level x time x dose coefficient

Annual Effective Dose (AED): it is necessary to calculate the annual effective dose due to inhalation of radon gas exposure within the environment is estimated using the formula suggested in (UNSCEAR.,2000).

Mathematically, the formula is given as:

$$D_{W(inhalation)} = C\ x\ F\ x\ T\ x\ DCF$$

C = radon concentration Bq/m^3

F= 0.8(occupancy factor)

T= 8760 hours / year

DCF = $9\ x10^{-6}$mSv per $Bq.h/m^3$

Inhalation Dose: 60% of AED

Exhalation Dose : 40% of AED

Where, $D_{W(inhalation)}$ is the annual effective dose due to inhalation of radon release to air from the environment ($mSv\ y^{-1}$), F is the indoor occupancy factor ($h\ y^{-1}$), EF is the indoor radon-progeny equilibrium factor ($EF = 0.4$) and DCF is the inhalation dose conversion factor for ^{222}Rn ($DCF = 9.0 \times 10^{-9}$ Sv $Bq^{-1}\ h^{-1}\ m^3$), T is the number of time taken for the radon factor to result.

Radon inhalation rate: This is the number of radon gas absorbed per unit surface area per unit time within the environment, radon levels can vary significantly within a building and even hour to hour.

Radon exhalation rates: The number of radon gas released per unit surface area per unit time within the environment is termed as exhalation rate

hence $E\ o = (C\ \infty\ (\lambda + \lambda\ b + \lambda\ v) - \lambda\ v\ C\ o)\ V\ A$ Where, the equilibrium radon concentration C_∞ can be measured directly and use λ_v and λ_b , Leakage rate, 2.3 and Back diffusion rate, respectively.

Excess life cancer risk: The mean excess lifetime cancer risk (ELCR) values were expected in the range of 0.1% - 4.26% accompanying an overall average value of 1.01%.

ELCR= AED x DL x RF

Where DL and RF are called the average lifetime duration and fatal cancer risk factor per sievert

to 70years (average life) and 0.005 Sv^{-1}

Results

The mean recorded radon values concentration varies in different locations where results were obtained the study area which falls within the WHO accepted range $100Bq/m^3$

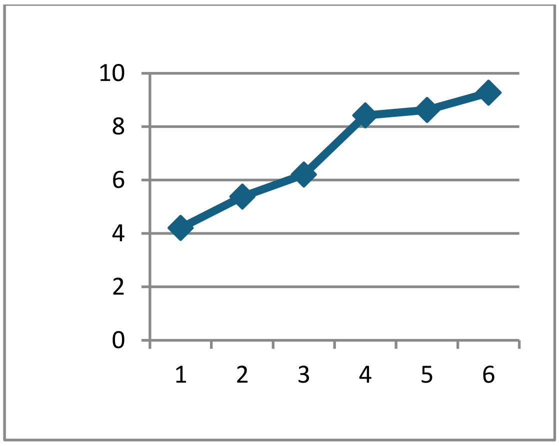
Table 3.1 Average values of the estimated radiation risk parameters of six locations of the study area were taken which includes radon concentration, radon inhalation, radon exhalation rates, excess lifetime cancer risk due to exposure to 222Rn radon gas and Mean values.

Table 2: Shows the radon activity, AED, radon inhalation, Radon exhalation, EXCLR, Mean values of Ebu, Akwu-ukwu igbo, Illah, Okpanam, Ugbolu and Ukala these are the six locations as the case study

Radon Activity (bq/m^3)	AED (mSv/yr)	Radon inhalation dose (mSv)	Radon exhalation dose (mSv)	EXCLR (SV/Y)	Mean Values (In/Ex)
4.20	0.22	0.16	0.10	0.0092	0.130
5.38	0.30	0.20	0.15	0.0119	0.175
6.20	0.35	0.23	0.16	0.0136	0.195
8.42	0.53	0.32	0.21	0.0186	0.265
8.62	0.55	0.34	0.23	0.0189	0.275
9.27	0.59	0.38	0.26	0.0202	0.305

Chart 2 Radon activities concentration

Chart 2.1 above represents the statistical value comparison of radon activity



concentration for 6 different locations which the ranging from location 1 – 6 respectively these locations has their values as indicated

in table 3.1 and the summary of these data indicated that the study area is deemed safe.

Chart 2.2: Annual Effective Dose of the study area

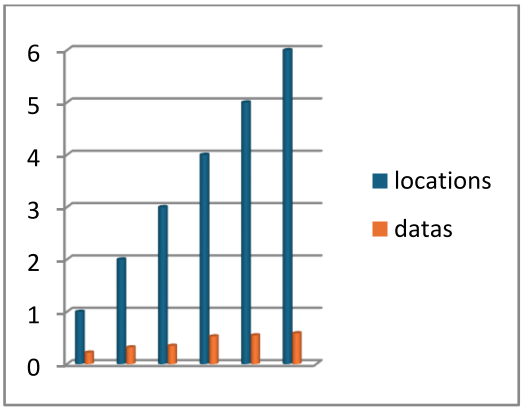


Chart 2.2 represents the Annual effective dose which were obtained in 6 different locations of the study area and it shows that the quantity of Annual effective dose which was compared to other research done previously like Osuji, L. C., & Avwiri, G. O. (2019) so when data were gathered and compared it shows that the

activities that's happening at the area of study is safe for the people within the environment.

CHART 2: Represents Radon inhalation rate against exhalation ratFig.2.3 represents the relationship between radon inhalation rate to radon exhalation rate of the study area if you look this chart closely you will realize that in the obtained results the higher the X-value which is the inhalation rate the lower the Y-value which is the exhalation rate and these obtained results were compared with the previous research done with Osuji, L. C., & Avwiri, G. O. (2019). Environmental radiation and health effects in the Niger delta region of Nigeria, international journal of environmental science in tables 4.6, meaning each result obtained from different locations was different because of the industrial and aerobical activities happening in each study area.

Discussion

The table 2.1 represents the activity concentration of ^{222}Rn gas released to the environment of the study area from the industries and cigarette smoke has its minimum and maximum values of the determined specific activities are represented in the table above ,the figures are as follows 4.20Bq/m^3 ± 8.40 (Bq/m^3), 5.38(Bq/m^3)± 8.60(Bq/m^3), 6.21Bq/m^3 ± 9.2Bq/m^3 , 8.42Bq/m3 , 8.62Bq/m3, 9.27Bq/m3 the mean values are 0.130(Bq/m^3), 0.175(Bq/m^3), 0.195(Bq/m^3) ,0.265Bq/m3, 0.275Bq/m3, Annual effective dose (AED) are follows 0.22 mSv/yr, 0.30 mSv/yr, 0.35 mSv/yr, 0.53 mSv/yr,0.55 mSv/yr,0.59 mSv/yr and the radon inhalation (Dw) are as follows 0.16 mSv ,0.20 mSv,0.23 mSv, 0.32 mSv,0.34 mSv, 0.38 mSv the obtained inhalation value was necessary to ascertain the quality of air intake of that area because for inhalation to take place exhalation must be involved, Then the exhalation values are as follows 0.10 mSv,0.15 mSv,0.16 mSv,0.21 mSv,0.23 mSv,0,26 mSv ,so the excess life cancer risk (EXCLR) for radon happens to fall within world average limit of 100Bq/m3 the mean concentration of the environmental radiation radon gas within the study area is termed permissive (Isinkaye M.O et al 2017). In Chart 2.1 Above represents the statistical comparison of radon activity concentration for location 1-6 respectively these locations has their values as indicated in table 3.1 and the summary of these data indicated that the study area is deemed safe for any aerobical activities, Chart 2.2 represents the statistical comparison of radon exhalation rates values which were taken in different locations namely locations of the study area and it shows that the quantity of Annual effective dose that takes place in the study area Fig.2.3 represents the relationship between radon inhalation rate to radon

value which is the exhalation rate and these obtained results were compared with the and health effects in the niger delta region of Nigeria, international journal of meaning each result obtained from different locations was different because of the industrial and aerobical activites happening in each study area.

Conclusion

In this research the radon gas ^{222}Rn of the study area was assessed, recorded and its health consequences was highlighted, The measured radon concentration on the environment from the areas of study Ebu, Okpanam, Illah, Ugbolu, Ukala and Akwuukwu-igbo , the radon detector was tested in this six locations in the Oshimili–north part of Delta state, Nigeria are presented in tables above the radon concentration ranges from 4.20Bq/m^3 ± 9.27Bq/m^3. On the results this is contributed to the accumulated and long residence time of the radon gas within the study area. Also, this type of gas has little accommodation for aerobical mechanism; therefore, the accumulated radon is termed average within the 6 locations of the study area. Due to the existence of radon gas found available at the environment like lands and buildings, every construction and open environment was checked using the radon detector called Alpha guard PRO 2000 with GPS location which is the major case study of this research after the conducted research the lands and the buildings of the study area was found to be conducive for the people living within the study area, it is advisable to allow conservation developments like trees and gardens so to enable enough ventilation for the people living within the area. The overall mean values after been converted ranged from 0.130Bq/m3 to 0.305 Bq /m3 and these obtained results were compared with other previous research to clarify no error was encountered during the collection of data from any of our detector machine. Several health and environmental protection agencies have recommended different safe criteria for radon concentration in the environment for the members of the public (Cardoso J.R.F, 2006). The results of this research were assessed with those criteria. The mean radon concentrations obtained from the study area were compared with other apst similar works done in different locations and the results falls within the recommended value of WHO which is 100Bq/m^3, thereby proves that the study area is safe for the people living within (UNSCEAR, 2006)

CONFLICTS OF INTEREST

The desired community for this research complied when the radon readings were being taken, it was a non-financial interest work so no conflict existed either between the community and the authors during and after the research, every party involved was respected two authors involved have no conflict of interest to declare this is sufficient.

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