Investigation of Exposure Level to Background Radiation Emitted From Laboratories in Cross River University of Technology (CRUTECH) Calabar, Nigeria.

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ABSTRACT: Comparative studies of background radiation emission from laboratories in Cross River University of Technology (CRUTECH) Calabar, Nigeria was carried out using a digital radiation meter (Soaks Ecotester) which is optimizing to measure alpha, beta and gamma background radiation. On the basis of measuring the radiation emission to ascertain the level of exposure to ionizing radiation which can cause injuries and clinical symptoms, which may include a chromosomal transformation, cancer induction free radical formation, born necrosis and radiation contragenesis. The result obtain in background radiation emission exposure rate, indicates that the workers and students entering inside physics, Biology, Chemistry and microbiology Laboratories are operating within the recommended safety limit of 1.0msv/yr. while Biochemistry, civil, Mechanical and Electrical engineering laboratories are operating at 11.6, 10.23, 9.53, and 8.83msv/yr respectively; which is above the threshold value. Proper survey is recommended in these laboratories to identify the radiation sources.

Keywords: Background radiation, Exposure Risk, Laboratory, safety limit, and Radiation dose

I. INTRODUCTION

Radiation monitoring is a very important precaution against over exposure to harmful ionizing radiation since we are inescapably exposed to environmental background radiation. This environmental ambient radiation varies in intensity and quality from place to place and from time to time. Ionizing radiation has the ability to affect the chemical state of a material and to cause changes which are biologically important [14]. Exposure to ionizing radiation can cause injuries and clinical symptoms; which may include a chromosomal transformation, cancer induction free radical formation, born necrosis and radiation catractogenesis [12]. The injuries and clinical symptoms could be caused by both chronic and acute dose exposure. Because of the lethal effect of ionizing radiation, the practice is to monitor and assess the level of exposure and keep one's exposure to ionizing radiation as low as reasonably achievable (ALARA principle). In this context, the main work investigate the natural background radiation level(Radon gas) in some laboratories through the contribution of gas to indoor radiation exposure rate, this is to enable us address the potential risk of lung cancer from breathing air containing the ejected alpha particles from alpha decay in radon, since lung cancer is now the leading cause of cancer death in both men and women worldwide; various researchers has reported the exposure to high level environmental radioactive pollutant at the laboratories, work place and public sectors and important risk factors for cancer[15]. In BEIR IV 1999, a model was derived for estimating the risk from inhaled radon progeny, based on analysis of epidemiological result. In the comparative dosimentry report, estimate of radiation dose to potential target cell in lungs were calculated under mines and residential conditions respectively, results were expressed in terms of a ratio k, representing the quotient of the dose of alpha energy per unit exposure to individual in a home compare to that of a miner in a mine, it was concluded that the dose per unit exposure was typically about 30% lower in homes than in mines(k=0.7), implying a 30% risk reduction in the risk coefficient applicable to office environment from what will be estimated from miner data. Subsequently, Environmental protection agency(EPA) sponsored another NAS study [11], which provided new risk models and estimates of the k factor, based on much more complete information [10]. Some new information had become available regarding exposure condition in mines and homes that led to a revised estimate of k.

Background radiation: Is the ubiquitous ionizing radiation that people on the planet earth are exposed to including natural and artificial sources. Both natural and artificial background radiation varies depending on location and altitude. Natural background radiation and radioactive materials found throughout nature, detectable amount occur naturally in soil, rocks, air and vegetation, from which it is inhaled and ingested into the body, in addition to this internal exposure from radioactive materials that remain outside the body and from cosmic radiation from space, the worldwide average natural dose to human is about 2.4 millisievert per year(msv/yr), this is four times more than the worldwide average artificial radiation exposure, which in the year 2008 amounted to about 0.6msv/yr in some rich countries like US and Japan. Artificial exposure is on average, greater than the natural exposure, due to greater access to medical imaging in Europe, average natural background exposure by country ranges from under 2msv annually in the United Kingdom to more than 7msv annually for some groups of people in Finland [12].

Some areas have greater dosage than the country-wide averages. In the world, exceptionally high natural background locales include Ramar in Iran, Guarapan in Brazil, Karunagappalli in India, Arkaroola in South Australia and Yangjiang in China.

The highest level of purely natural radiation ever recorded on earth's surface was 90µGλ/h on a Brazilian black beach (Areiapreta in Portuguese) composed of monazite. This rate would convert to 0.8Gλ/yr for a year round continues exposure, but in fact the levels vary seasonally and are much lower in the nearest residence. Another area of high background radiation is found in Ramar primarily due to the use of local naturally radioactive limestone as a bud ding material. The 1000 most exposed residents receive an average external effective radioactive dose of 6msv/yr(0.6rem/yr), six times more than the international commission on radiological protection(ICRP) recommended limit for exposure to public from artificial sources, the additionally receive substantial internal dose from radon, record radiation levels were found in a house where the effective dose due to ambient radiation field was 131msv/yr and the internal committed dose from radon was 72msv/yr. This unique case is over 80 times higher than the world average natural human exposure to radiation. Epidemiological studies are underway to identify health effect associated with the high radiation levels in Ramar, it is too early to draw statistically significant conclusions while so far support for beneficial effect of chronic radiation has not been observed, a protective and adaptive effect is suggested by at least one study whose authors nonetheless caution that data from Rama are not yet sufficiently strong to relax existing regulatory dose limits [12].

We are all exposed to radiation from natural and man-made source, just 20 Bqm^{-3} (average radon level in UK homes) gives us half our exposure to radiation from all source, higher radon levels gives higher exposure, that is why is important to find out the levels in your home and in your school or work place.

Radioactivity or radioactive decay discovered in 1886 by Henry Becquerel is a process by which an unstable parent nucleus transforms spontaneously into one or several daughter nuclei that are more stable than their parent nucleus. The type of radiation emitted can be identified by their ability to ionize, depth to which they penetrate matter and their behavior in a magnetic field [2].

Natural Radioactivity (NR) is due to naturally occurring nuclides. It is the spontaneous disintegration of the nuclei of heavy isotopes with the release of alpha particles, gamma rays and energy. Intensive research by Becquerel, Madame Carrie, Rutherford and others in 1896 led to the discovery of several other radioactive element like ^{234}Pa. if large fractions of the ^{234}Pa nuclei formed in the isomeric state, it will therefore decay by beta emission to ^{234}U. A natural radioactive nucleus transform with a given parent nucleus may undergo series of decay leading to the transformation of many daughter with different decay constant and half-life. Any radioactive source is characterized by an activity and half-life regardless of the nature of radioactivity. Therefore, radioactivity is defined as the rate at which the nuclei of the radioisotope species concerned decay with time [6].

i.e $dN = -\lambda N dt$

Therefore

$$\lambda N = -\frac{dN}{dt} \quad (1)$$

N = number of radioactive nuclei, dt= time of radioactive nuclei decay, λ= decay constant.

The minus sign indicates that N decreases from N_o value at time t.

Integrating equation (1)

$$\int_{N_0}^{N} \frac{dN}{N} = -\lambda \int_0^t N$$

$$[lnN]_{N_0}^{N} = -\lambda t$$

$$\ln N - \ln N_o = -\lambda t$$

$$\ln[N/N_o] = -\lambda t$$

$$N = \ln(-\lambda t) N_o$$

Emplies that

$$N = N_o e^{-\lambda t} \quad (2)$$

Equation two (2) is the fundamental law of radioactive decay.

Decay law states that a radioactive substance decays exponentially with time at half-life (Ervin, 2010).

i.e $N = N_o/2$ and $t = T_{1/2}$

Therefore, $N_o/2 = N_o^{e-\lambda}\, T_{1/2}$

$\ln/2 = -\lambda\, T_{1/2}$

$$T_{1/2} = 0.693/\lambda \qquad (3)$$

The decay constant λ is independent of the age of the radioactive atom and is essentially independent of physical conditions such as temperature, pressure, and chemical state of the atom's environment. Careful measurement has shown that λ can actually depend slightly on the physical environment [2].

Artificial radioactivity is due to the bombardment and fusion of stable light element with neutrons by bombarding their nucleus with alpha particles, proton or neutron with the emission of same radiation as in natural radioactivity [9].

Absorption of radiation by matter: Alpha and beta particles are absorbed in matter by ionizing kinetic energy in ionizing encounters with atom of the absorbing medium; i.e an electron is knocked of an atom to form an ion-pair. When they have no more enough energy to produce any ion-pair the ionizing radiation are said to have been absorbed [5]. Gamma rays are usually most strongly absorbed by elements of high atomic number such as lead. The absorption process is complex, whereas the alpha or beta particles gradually lose kinetic energy by series of ionizing encounters with electrons belonging to atom of the absorber, gamma ray may interact with an electron or nucleus in several ways if the energy is enough. The energy given up is responsible for the ionization created in a gas by gamma rays. This enable gamma ray to be detected by Geiga- muller(G-M) tube [7].

Radiation exposure Dose: The quantity of the flux of radiation at a place of study is known as exposure dose. Roentgen(R) is the unit of exposure and is defined as the exposure of gamma ray that result in the production of ions of either sign to the extent of 2.58×10^{-4}C of charge released per kilogram of dry air i.e $1R = 2.58 \times 10^{-4} Ckg^{-1}$.

Radiation: Electron volt(eV) is the unit of measurement of radiation energy and is defined as the kinetic energy gain by an electron by its acceleration through a potential difference (p.d) of 1volt. i.e

$1eV = 1.602 \times 10^{-19}J$

Dose: The absorbed dose is measured in both traditional units called rad and an international system(S.I) unit called gray(GY); 1GY = 100rad [3].

Sources of ionization radiation: sources of ionization radiation are of two types;

External radiation sources which comes from natural and man-made sources of ionizing radiation that are outside the body. Some of natural radiation is cosmic rays from space. This is often given out by radioactive material in the soil and building material, mining site, quarry site etc around us. Human activities have left on the land higher levels of natural radioactive material, such activities as manufacturing of fertilizer, burning of coal in plant mining and purifying Uranum [4].

Internal radiation is ionizing radiations which are natural and man-made radioactive material given off while they are inside the body. Radioactive material enters into the body by air we breathe, food we eat, and the water we drink as in coal mine environ; low amount of material that act as source of ionizing radiation may also be contracted for medical purposes to test for threat of some type of disease [4].

Effect of ionizing radiation: the effect of ionizing radiation on geological matter depends on the size of the dose. The dose in turn depends on the radioactive material. It chemical form, how it was taken into the body and how quickly it leaves the body. Over exposure or accumulation over time to high amount of ionizing radiation can lead to hazardous effect like skin burns, hair loss, birth defect, cancer mental retardation (a complex nervous system functional ability) and death. Others are sterility, mutation of gene etc [1].

II. MATERIALS AND METHOD

An insitu approach of Background Radiation Measurement was adopted using direct dosimetry. A SOEKS ecotester Geiger counter + food Nitrate tester digital alert Background radiation monitor was used. The radioactive detector was suspended where the ventilation slits will not be blocked and such that it is 1.00m above the flow; a height in the breathing zone of a seated person. The detector was at least 0.90m from doors, windows or any other opening in the walls, the Geiger tube generates a pulse of electrical current each time radiation passes through the tube and cause ionization. Each pulse is electrically detected and registered as a count in milli-Sievert per hour (mSv/hr). The measurement was done from three angles of each laboratory in Cross River University of Technology (CRUTECH) Calabar campus and the average calculated with their precisions. To convert the average dose rate per hour into an equivalent dose in milli-Sievert per year (mSv/yr), the equation (4) was used:

Indoor: (x) mSv/hr x 8760hr/yr x 0.2 x 0.001 = OAEDR (mSv/yr) [13] (4)

III. RESULT AND DISCUSSION

Table 1: Field data and calculated OAEDR

S/N	Location	Average Dose Rate(msv/hr)	IAEDR (msv/yr)
1	Physics Lab.	0.11	0.77
2	Biology Lab.	0.13	0.91
3	Chemistry Lab.	0.13	0.91
4	Biochemistry Lab.	1.66	11.60
5	Civil Engr. Lab.	1.46	10.23
6	Mechanical Engr. Lab. I	1.36	9.53
7	Mechanical Engr. Lab. II	1.33	9.32
8	Microbiology Lab.	0.12	0.84
9	Electrical Engr. Lab.	1.26	8.83

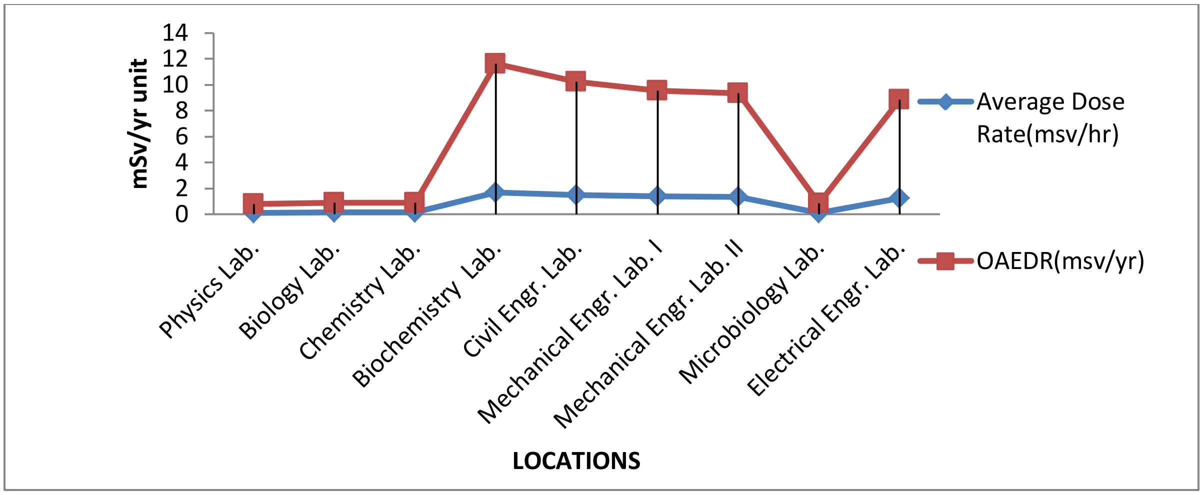

Fig. 1: Plot of emitted dose with various locations

UNSCEAR, 1998 recommended indoor and outdoor occupancy factor of 0.8 and 0.2 respectively. This occupancy factor (OF) is the proportion of the time during which an individual is exposed to a radiation field [13]. This work is based on indoor exposure and indoor occupancy factor of 0.8 was used to determine the indoor annual effective dose rate (IAEDR). 8760 hours per year was used to calculate the IAEDR.

On the basis of measurement of background radiation emission in CRUTECH laboratories, result (background radiation exposure rate) after data collection shows that the highest radiation exposure level in CRUTECH laboratories Calabar campus, are found to be 1.66mSv/hr and the IAEDR is found to be 11.6mSv/yr as shown in fig.1. The values determined are found to comply with the threshold value set by ICRP of 1.0mSv/yr in Physics, Biology, Chemistry, and Microbiology Labs; but the threshold value of 1.0mSv/yr was exceeded in Biochemistry, civil Engineering, Mechanical Engineering I&II, and Electrical Engineering Laboratories.

IV. CONCLUSION

The annual radiation dose limits set by the regulatory agencies (ICRP, NRCP, NRC etc) as the appropriate safety standard to control and limits the potential harmful radiation effect have set the effective dose or the number of the public not to exceed 1.00mSv/yr. in the study some locations under investigation meet the standard set by ICRP of 1.00mSv/yr while some locations exceeds the threshold value 1.00mSv/yr. more advance method should be employed to identify the specific radiation source in such locations. Also students and technologies should be conscious as they spend most of their time in such laboratories as to reduce the effect to exposure.

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