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ORIGINAL ARTICLE

ASSESSMENT OF ENVIRONMENTAL RADIOACTIVITY AROUND COAL MINE AT OKABA, KOGI STATE NIGERIA

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ABSTRACT: Environmental radioactivity assessment was carried out around coal mine at okaba. This was done using a digital radiation meter (INSPECTOR 06250 MODEL) which is optimise to measure alpha, beta and gamma radiation. On the basis of measurement of environmental radioactivity around coalmine at okaba, result obtained in exposure rate (mR/hr) after data analysis shows that the highest radiation level at Okaba coal mine was found to be 840.96mR/yr or 1009.152mrem/yr. The result indicates that the workers at okaba coalmine are operating within the recommended safety radiation limit of 2rem/yr as prescribed for workers by the International Committee on Radiological protection (ICRP).

KEY WORDS: Okaba, Coal mine, Radioactivity, Exposure level, Assessment, ICRP.

INTRODUCTION

Radioactivity or radioctive decay discovered in 1886 by Henry Bacquerel is a process by which an unstable parent nuclues transforms spontanuosly into one or several daugther nuclei that are more stable than their parent nucleus. The type of radiation emitted can be identified by their ability to ionise, depth to which the penetrate matter and thier behavior in a magnetic field (Ervin, 2010; Osang *et al.*, 2013a).

There are two types of radioactivity Natural and artificial;Natural radioactivity(NR) is due to naturally ocurring nuclides. It is a spontaneous disintegration of the nuclei of heavy isotopes with the relaese of alpha particles, gamma rays and energy. Intensive research by Bacqueral, Madame Carrie, Rutherford and others in 1896 led to the discovery of several other radioactive element e.g ^{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 (Pollock *et al.*, 2010).

A natural radioactive nuclues transform with a given parent nuclues may undergo series of decay leading to the transformation of many daughters with different decay constant and half-life. Any radioactive source is characterised by an "activity" and half-life regardless of the nature of radioactivity. Therefore, is define as the rate at which the nuclei of the radioisotope species concerned decay with time (Delaney and Finch, 1992).

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

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

$$\int_{No}^{N} dN/N = -\lambda \int_{0}^{t} N$$
$$[\ln N]_{No}^{N} = -\lambda t$$
$$\ln N - \ln No = -\lambda t$$
$$\ln N / No = -\lambda t$$
$$N = \ln(-\lambda t)N_0$$
Emplies that
$$N = N_0 e^{-\lambda t} \quad (2)$$

Equation two (2) is the fundamental law of radioactive decay.
Dacay law states that a radioactive substance decays exponentailly with time at half-life (Ervin, 2010).

i.e $N = N_0/2$ and $t = T_{1/2}$
Therefore, $N_0/2 = N_0 e^{-\lambda T1/2}$
$Ln/2 = -\lambda T_{1/2}$
$$T_{1/2} = \frac{ln/2}{-\lambda} = 0.693/\lambda \quad (3)$$

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. Carefull measurement have shown that λ can actually depend slightly on the physical environment (Ervin, 2010).

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Artificial radioactivity is due to the bombardment and fussion of stable light element with neutrons by bombarding thier nucleus with alpha particles, proton or neutron with the emission of same radiation as in natural radioactivity (Murray, 1993).

1.1. 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, that is 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. Gamma rays are usually most strongly absorbed by elements of high atimic number such as lead. The absorption proccess 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, gama 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 (John, 1981).

1.2. Radiation exposure Dose

The quantity of the flux of radiation at a place of study is known as exposure dose. Roentagen (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 X 10^{-4}C of charge released per kilogram of dry air i.e 1R = 2.58 X10^{-4}Ckg^{-1}.

1.3. 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 X 10^{-19}J

1.4. Dose

The absorbed dose is measured in both traditional units called rad and an international system(S.I) unit called gray(GY); 1GY = 100rad (Max, 2007).

1.5. Sources of ionization radiation

sources of ionization radiation are of two types;
External radiatipon source 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, quary 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 (NIOSH, 2010; Osang *et al.*, 2013b).
Internal radiation is ionizing radiation 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 breath, 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 (NIOSH, 2010).

1.6. 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, the amount of activity, the type and energy of radiation, the effective half-life of 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 hazadous effects like skin burns, hair loss, birth deffect, cancer, mental retardation(a complex nervous system functional ability) and death; others are sterility, mutation of gene, cataracts etc (ATSDR, 1999; Obi *et al.*, 2013).

1.7. Coal

It is organic in origin. When trees, plants and algae die in the semi-tropical swamps, they accumulate in the bottom of a layer. This layer is called peat which is covered by sand and clay deposite. The pressure due to the soil layers deposited squeezes out the water from the peat layer. This will change the paet into pulpy mass intermingled with fragments of wood. This is called lignit, further increase of density leads to bituminous coal. It is black and shinny; A higher grade of coal is the anthracite, which can be formed on additional pressure. It has a high-fixed carbon content. However it takes about 3000years to form 0.305m of bituminous coal. Coal energy is present in the the form of carbon and hydrogen. Anthracite may have 96% fixed carbon while lignite has 38%. The heating value of anthracite is 2.68 X 10^{7}KJ/tonne while bituminous coal has 2.76 X 10^{7}KJ/tonne, lignite has 1.5 X 10^{7} – 2.7 X 10^{7} KJ/tonne heating value. Coal companies are mainly oil companies and metal manufacturers. There are also coal-fired boilers in industries. The Oji power station and Ajaokuta steel company in Nigeria runs on coal. It takes seventy eight(78) years to get a new mine into production. Mines abandoned are not safe to enter and they hardly be put into production again (DHHSC, 2013).

1.8. Pollution problem of coal

The dusty air of the mine has incapacitated many miners, the use of high-pressure jet of water to fracture the coal may reduce this but this courses water pollution. Large regions are turned into wastland with little hope of turning them back into natural landscapes. Coal contaian up to 5% sulphure in addition to about 36 other chemicals that may act as pollutants. When this sulphure is exposed to the atmosphere it causes yellow-gray acid to drain into the stream, killing life and plants and other structures. The smoke and gas that arise from burning of coal in industries like coal-powered station contribute to the air pollution of our world. The smoke particles can course respiratory problem. Randon gas is also produced when fossil fuels like coal are burnt. This leads to increase in radioactivity in the air around power stations and coa mines (ATSDR, 1999; Osang *et al.*, 2013c; *Obi et al.*, 2013).

1.9. Coal mine safety measures

Protection and precaution against gases must be taken in mines. There are many gases that displaces oxygen in air and make it unsafe to breathe. One of this gases is carbondioxide(CO_2). This gas is often found with deeply buried deposite of coal. Air which contaians large proportion of CO_2 is called chokedamp or blackdamp, it can be detected by an instrument called flame safety camp. Chokedamp becomes hazaduos when a section of the mine is cut off from proper supply of fresh air, and the coal or the mine timber support absorbs oxygen from the air.constant ventilation of all parts of the mine prvents chokedamp. Other gas found in mines is carbonmonoxide (CO) and it is caused by incomplete burning of coal (ATSDR, 1999; Osang *et al.*, 2013c; Ewona *et al.*, 2013).

1.10. Study Area

The actual coal mining site is at Odagbo, on the outskirts of Okaba. Okaba district lies some 16km NE of Ankpa town, headquarters of Ankpa Local Government Area, Kogi State (Figure 1). The study area is located between latitudes 70201- 70431N of the Equator and longitudes 70221 - 70521E of the Prime Meridian. The area is within the tropical hinterland. Annual rainfall totals range between 100-200cm, spread over 6-8months. Earlier investigations by workers such as De Swardt and Casey (1961) indicate that the lower coal measures at Okaba contain a high proportion of shale and sandy shale. A few outcrops of the false-bedded sandstones occur. The soils are clayey, muddy and difficult to traverse when wet (Federal Department of Agriculture and Land Resources, 1990). The inhabitants of Okaba district are mainly Igala-speaking people, who have lived a sedentary lifestyle, engaged in agrarian pursuits of cultivating arable crops and rearing livestock on a free-range and semi intensive basis (Ogwuche and Odoh 2013).

MATERIALS AND METHODS

The instrument used is the geiger counter (inspector 0625 model). It has an inbuilt calibration mechanism for the measurement of Alpha, beta, gamma and X-rays. It is a health and safety instrument that can detect a low level of radiation emission or radioactivity. The instrument equally measure radiation parameter such as dose rate (0 to 5000μSv/hr), exposure rate (0.001 to 100mR/hr) and activity (0 to30,000Cpm). It has a 4-digit liquid crystal displayed including mode indicator. It is ±13% up to 130, 000Cpm activity acurate. The values were converted to mR/yr and subsequently to mrem/yr in conformity with the standard used by ICRP.

RESULTS

The result of the radioactivity in count per minites (Cpm) and exposure rate in milli-Roentengen per hour(mR/hr) as measured at okaba coal mine are presented in table (1) and backgroud parameters in table (2).

Table 1: measure values

S/N & Site	Activity (Cpm)	Exposure rate (mR/hr)	Exposure rate (mR/yr)	Exposure Rate (mrem/yr)
1	189	0.077	674.52	809.424
2	194	0.079	692.04	830.448
3	202	0.085	744.60	893.520
4	200	0.084	735.84	883.008
5	198	0.083	727.08	872.496
6	210	0.019	166.44	199.728
7	220	0.096	840.96	1009.152
8	208	0.090	788.40	946.080

Table 2: Background Values collected from the sites

S/N & Number of Sites	Background Activity(Cpm)	Background Exposure rate (mR/hr)	Background Exposure rate(mR/yr)	Background Exposure Rate(mrem/yr)
1	30	0.008	70.08	84.096
2	24	0.009	78.84	94.608
3	14	0.008	70.08	84.096
4	16	0.008	70.08	84.096
5	14	0.008	70.08	84.096
6	15	0.009	78.84	94.608
7	16	0.008	70.08	84.096
8	15	0.008	70.08	84.096

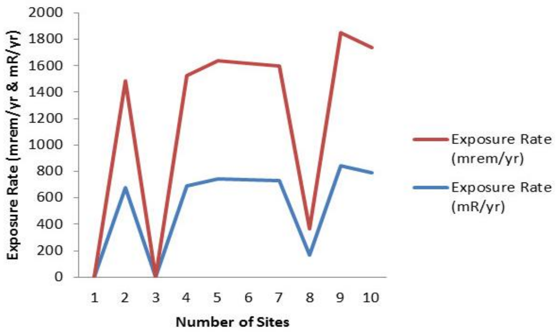

Figure 1: Graph Exposure rate against number of sites

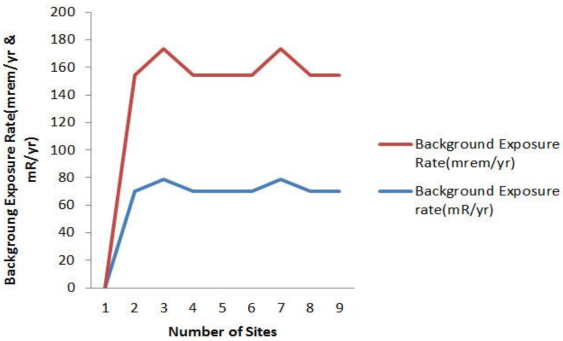

Figure 2: Graph of Background Exposure Rate against Number of sites

DISCUSSION

On the basis of measurement of environmental radioactivity around coalmine at okaba, result (exposure rate) in mrem/yr, after data analysis shows that the highest radiation level at Okaba coal mine was found to be 840.96mR/yr or 1009.152mrem/yr Figure (1). The result indicates that the workers at okaba coal mine are operating within the recommended safety radiation limit of 2rem/yr as prescribed for workers by the International Committee on Radiological protection (ICRP). The background radiation(activity) is also tolarable; it falls within 70.08 – 78.84 or 84.096 – 94.608mrem/yr as shown in Figure (2), Lower than that of the continental united state and Brazil of 295mR/yr and 500-1000mR/yr respectively (Max, 2007).

CONCLUSSION

The scope of the research is mainly on environmental assessement of radioactivity around okaba coal mine and the rate of exposure to workers. The coal mine under investigation meet the standard as set by ICRP of 2rem/yr and background radiation equally tolerable for workers. However, late effect (stochastic and deterministic) should be studied. Genetic conditions are important regarding the susceptibily to some late effect. Environmental conditions before, during and after exposure also play a role on the incidence and timing of the late effect observed. Individuals exposed to low levels of radiation over a period of time will eventually show late effect also referred to as delayed effect of radiation (Max, 2007).

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