TETFUND/UNIBOKKOS/ARJ/3

MEASUREMENT OF ^{222}Rn CONCENTRATIONS IN MINERAL PROCESSING INDUSTRIES WITHIN JOS AND BUKURU MERTOPOLIS

Adetona .A. E, Mangset .E. W and Masok .F. B
Department of Physics, Faculty of Natural Sciences, University of Jos, Nigeria
Department of Industrial physics, Plateau State University, Bokkos.
eadetona91@yahoo.com

ABSTRACT

Radon has been recognized as one of the health hazards for mankind because long term exposure to radon increases the risk of developing lungs cancer. In this study, concentration of radon-222 in tin processing industries within Jos and Bukuru metropolis was determined. This was achieved by using a safety siren pro radon gas detector. The equipment was exposed to air at four different positions in the industries visited. Results obtained from the study indicate that the concentration of ^{222}Rn varied between 503.0Bq/m^3 and 814Bq/m^3 which is extremely high compared to the accepted concentration of 148Bq/m^3 by USEPA 2014. Also, the dose received by the workers in the firm was calculated and it varied between 9.84mSv/year and 11.25mSv/year which falls within the acceptable limit of 20mSv/year by the world health organization but is very high for non-radiation workers and the general public whose permissive value is 5mSv/year and 1msv/year respectively.

KEYWORDS: Radon, Mineral Processing, younger granites, Radon gas detector.

INTRODUCTION

Radon is a naturally occurring gas that contributes to radiological contamination of the environment which poses a health risk to the populace. Since the late 1980s, radon has been identified as highly dangerous to the health of human. Radon is a naturally occurring radionuclide formed from decaying uranium or calcium radium deposits. Thomas in 1987, reported that majority of areas with high radon concentration are those underlain by granic rocks that contain higher levels of radon precursors. It escapes from the earth's crust and through cracks and cervices in bedrock. It can also dissolve in ground water or seep through foundation cracks into the environment/human habitations (Garba 2011).

Once radon is produced, it moves towards the surface and decays to a series of elements. The

decay products or daughters move less freely in air than the radon itself. As a result, they eventually attach to dust particles in the atmosphere and when inhaled, it becomes a health problem if not properly filtered by the nose.

The occurrence of tin and columbite in the Jos plateau brought about intense mining activities in the state. Mining is achieved from exploration through exploitation to processing and finally to the consumer (Ogezi, 1998). The open cast mining method was generally used in predominantly flat plains of the plateau, as tin and columbite were concentrated in old stream beds (alluvial), having been washed down from the younger granite outcropping units(Falconer, 1921). The mining industry on the Jos plateau has cause extensive manmade environmental damage, with vast tracks of pastoral land systematically destroyed in the quest for casserite and columbite, with increased radioactive waste as a result of dumping of mine tailing and several heaps of mine dumps (over burden) and also mine ponds scattered all over the area. Also, the processing of these minerals has given rise to extensive quality of Mine tailings which are around ten times more radioactive than younger granites (Mangset and Sheyin, 2009).

In this study, the concentration of ^{222}Rn was measured in tin processing industries within Jos and Bukuru metropolis and it is expected that the concentration of the gas (Radon) in air in and around places where mineral processing is ongoing is expected to be high compared to places where processing activities do not take place.

The area of study includes the Jos and Bukuru metropolis where mineral processing has been in existence on a very large scale for decades. These areas are also known to have large mineral deposits.

The Jos Plateau is dominated by three rock types. The older granites that date to the late Cambrian and orduvician. The younger granites are emplacements dating to the Jurassic, and forming part of a series that includes the Air massif in the central Sahara. There are also many volcanoes and sheets of newer basalt extruded since the Pliocene (Morgan 1983). The older granites contain minerals such as quartz, feldspars, biotite, muscaite, hornblende and microcline. The accessory minerals include zircon, magnetite, apatite, and some opaque minerals which are radioactive. The younger Granites are rich in tin which was mined during and after the colonial period.

MATERIALS AND METHODS

Materials

The materials used for this research are; a siren pro 3 radon gas detector, a battery to power the detector and an umbrella to shield the detector from direct contact with sunlight or rain.

Data was collected in seven different mineral processing industries within Jos and Bukuru metropolis. The industries are: National Mineral Development Co-operation (NMDC) Jos, Ibrahim Tin shed Shagari Corner Jos, Chuks Mines Katako Jos, C.A Menta and Mines Alheri Jos, Chike Mines Bukuru, A.M Dungs Mines Dadinkowa Jos, Emperor Mines Bukuru.

At each of the industries visited, the Gas detector was placed at four different locations which are briefly explained in subsequent paragraphs. The detector was placed in the mineral processing unit and was monitored for hours after which the observed data was recorded. The detector was then relocated to the staff office where some of the processed minerals are kept. The staffs equally spend quality time here. The detector was observed for hours as well and the concentration was recorded. The detector was equally placed on the tailings. Tailings are materials left over after the process of separating the valuable faction from the worthless fraction of an ore. This product has no financial gain to the mineral operator at that particular point in time. The equipment was shielded from direct contact with sunlight using an umbrella, it was observed as well, and the data was recorded. Finally, to determine the variation of the data concentration in air with respect to distance, the concentration of the gas was measured at about 10m away from the mineral processing industry.

RESULTS

Processing unit

Table 1: Radon concentration in mineral processing units

S/NO	MINERAL PROCESSING INDUSTRIES	MINERAL PROCESSING UNIT (Bq/m^3)
1	NMDC	614.20
2	C.A MENTA AND MINES	629.00
3	IBRAHIM TIN SHED	658.60
4	CHUKS MINES	640.10
5	EMPEROR MINES	621.60
6	A.M DUNGS	651.20
7	CHIKE MINES	706.70
	AVERAGE	645.91

Staff Office

Table 2: Radon concentration in the staff office

S/NO	MINERAL PROCESSING INDUSTRIES	STAFF OFFICE (Bq/m^3)
1	NMDC	610.50
2	C.A MENTA AND MINES	625.30
3	IBRAHIM TIN SHED	636.40
4	CHUKS MINES	625.30
5	EMPEROR MINES	620.60
6	A.M DUNGS	691.90
7	CHIKE MINES	701.40
	AVERAGE	644.47

Tailings

Table 3: radon concentration on mining tailings

S/NO	MINERAL PROCESSING INDUSTRIES	TAILINGS (Bq/m^3)
1	NMDC	617.10
2	C.A MENTA AND MINES	643.80
3	IBRAHIM TIN SHED	663.80
4	CHUKS MINES	658.00
5	EMPEROR MINES	629.00
6	A.M DUNGS	695.60
7	CHIKE MINES	814.00
	AVERAGE	674.47

Outside The Mineral Processing Industry

Table 4: radon concentration outside the mineral processing industries

S/NO	MINERAL PROCESSING INDUSTRIES	OUTSIDE THE MINERAL PROCESSING INDUSTRIES (Bq/m^3)
1	NMDC	558.30
2	C.A MENTA AND MINES	540.10
3	IBRAHIM TIN SHED	525.30
4	CHUKS MINES	506.80
5	EMPEROR MINES	514.20
6	A.M DUNGS	573.40
7	CHIKE MINES	503.00
	AVERAGE	531.59

Risk to Workers in the Mineral Processing Industries

Denman and Parkinson (1996) estimated the dose received from radon to occupants in overground workspace, schools and domestic properties using the formula, which was applied by Gillmore (2001) to mines.

$$Dose\ (mSv) = \frac{Radon\ Concentration\ (Bq/M^3) \times duration, hours}{12600} \quad (1)$$

The above equation assumes an equilibrium factor (F) 0.5

Table 5: average radon concentration in each mineral processing industries and the dose (mSv/year).

S/No	MINERAL PROCESSING INDUSTRIES	AVERAGE RADON CONCENTRATION (Bq/m^3)	DOSE (mS/yr)
1	NMDC	607.52	10.03
2	C.A MENTA AND MINES	609.55	10.06
3	IBRAHIM TIN SHED	619.73	10.23
4	CHUKS MINES	607.55	10.03
5	EMPEROR MINES	596.00	9.84
6	A.M DUNGS	653.03	10.78
7	CHIKE MINES	681.28	11.25

DISCUSSIONS

Processing unit

Highest ^{222}Radon concentration obtained from the mineral processing unit in mineral processing industries visited within Jos and Bukuru metropolis was 706.7Bq/m^3 from Chike mines in Bukuru. This is because the processing activity is very intense with about five machines working at the same time unlike in other firms with only one or two machines. The concentration obtained from all the firms visited is shown in table 1.

The high radon concentration from these areas may be related to the radon source (^{238}U and ^{226}Ra) in the raw materials that undergo crushing and other processes in the mineral processing unit before reaching the final product.

The high concentration in the processing unit possess a high health risk to the workers because they all spend quality in this unit daily and they work with little or no shielding at all.

Staff Office

Highest concentrations of radon gas from staff office were obtained from Chike mines and AM Dungs with a mean concentration of 701.40Bq/m^3 and 691.90Bq/m^3 respectively. The range of the concentration of this gas in the staff office in virtually all the firms visited is almost the same with the concentration in the processing section which is very high compared to the USEPA accepted concentration. This is because the processed minerals are stored in the staff office before they are sold to the consumers. The high concentration in the staff office possess a very high health to visitors to the firm, buyers of their products and most importantly the staff as this is one place they take their rests or carry out some other duties. The concentration in various is shown in table 2.

Tailings

Tailings are also known as tail pile, tail leach residue or materials left over after the process of separating the valuable faction from the worthless fraction of an ore. These are waste of no financial gain.

This was confirmed to have the highest concentration of radon in all the mineral processing firms visited with Chike mines in Bukuru having an average concentration of 814.00Bq/m^3.

The high radon concentration of this tailing is because they contain heavy accessory zircorn, Monazite, Xenotite, limonite, magnetite, some columbite and casserite. These radioactive elements remain active for a very long period of time and will continue to be potentially dangerous. The plot of

the concentration is shown in table 3 above.

Outside The Mineral Processing Firm

At about 10 meters away from the firm, there was a significant decrease in the concentration of the gas compared to the concentration measured at the other locations within the mineral processing industry. This may be attributed to the fact that keeping distance from a radioactive source is important in minimizing exposure. The plot of the concentration is shown in table 4.

Risk to Workers in the Mineral Processing Industries

The risk is therefore dependent on the time spent in a mine and the level at that point. In the industries visited, workers spend an average of 8hours per day which corresponds to 40 hours per week, with a total of 2,080 hours in a year. The risk was calculated using equation 1 and the result obtained is presented in table 5.

CONCLUSION

Seven different mineral processing industries were visited to collect data for this research. At each of the industries visited, the concentration of ^{222}Rn was measured in four locations i.e. the mineral processing unit, staff office, mine tailings and 10m away from the mineral processing unit.

Measurement from this research indicates that the highest concentration of ^{222}Rn was on the mining tailings with a mean concentration of 674.47Bq/m^3 and then the concentration in the staff office having an average of 644.62 Bq/m^3 and finally outside the industry with a mean concentration of 536.9 Bq/m^3. All of which is far higher than the accepted concentration by USEPA 2014 of 148Bq/m^3.

On the other hand, the minimum concentration was obtained outside the firm which indicates that the concentration decreases as the distance increases according to the inverse square law.

Also, the average absorbed dose by the workers in the mineral processing industries still falls within the accepted limit for a radiation worker which is 20mSv/year.

In all, the overall result indicates that there is need for remedial action to be taken in all the mineral processing industries within Jos and Bukuru metropolis as the concentration of the gas is exceedingly higher than the minimum acceptable limit by USEPA and these industries are located within market places, residential areas and schools

thereby exposing people to the gas.

The ^{222}Rn concentration in mineral processing industries within Jos and Bukuru metropolis were determined using the safety siren pro series 3 radon Gas detector. Data obtained from this study indicates that the mean Radon concentration from in the mineral processing section varies between 614.20Bq/m^3 – 706.70 Bq/m^3 with an average of 645.91Bq/m^3. In the staff office, the concentration of the gas varied between 610.50Bq/m^3 – 701.40 Bq/m^3 with an average of 644.47Bq/m^3. On the mine tailings, the concentration varied between 617.10Bq/m^3 – 814.00 Bq/m^3 with an average of 674.47Bq/m^3 and finally at about 10 meters away from the mineral processing firm, the concentration of the gas varied between 558.30Bq/m^3 – 503.00 Bq/m^3 with an average of 531.59Bq/m3. These values are very high compared to the maximum permissive value of 148Bq/m^3 by USEPA. This implies that the staffs of such industries are likely to suffer cancer of the lungs as they spend quality time every day of their lives in this place. The public is also at a great risk of suffering the same fate because these minerals processing firms are located in commercial and residential areas.

REFERENCE

Denman, A.R and Parkinson, S. (1996): Estimates of Radiation dose to National Health Service workers in Northamptonshire from raised radon levels. Short communication, *The British Journal of Radiology*, 69, 72-75.

Falconer, J.D. (1921) Geology of plateau tin fields. *Bulletin of Geological survey of Nigeria*:1

Garba, N.N., Rabi'u, N., Yusuf, A.M., Ismaila, A., (2008) Radon: its consequences and Measurement in our living environs. *Journal of Research in Physical Sciences* 4(4), pp23-25.

Garba. N.N, (2011). Determination of radon concentration in water sources of Zaria and Environs using liquid scintillator counter. Unpublished M.Sc. thesis, A.B.U, Zaria.

Glimore, G.K. (2001) radon levels in abandoned metalliferous mines, Devon, Southwest England, Ecotoxicology and Environmental Safety, 49, 281, 281-292.

Mangset. W.E and Sheyin. A.T (2009). Measurement of radionuclide in processed mine Tailings in Jos, plateau state. *Bayero journal of pure and applied sciences.* Vol 2 (2) pp56-60.

Morgan, W.T.W (1983) Nigeria. Longman London.

Ogezi, A.E. (1998). Impact of mining on Nigeria Environment. *In FEPA monograph2, Towards pollution Abatement in Nigeria.*

Thomas, M.A. (1987). A Connecticut radon studying-using limited water sampling and a State wide ground-based gamma survey to help guide an indoor air testing program. *A progress report in Barbara, G. (ed), Radon, Radium, and other Radioactivity in Airborne contamination.* Proceeding of a conference, National Water Works Association, Lewis publishers. Pp 347-362.

United States Environmental Protection Agency (2014) A citizen's Guide To Radon: EPA Publications, EPA-402/C-12/001.