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A SURVEY OF BACKGROUND RADIATION DOSE RATES AND EFFECTIVE DOSE IN TWO SELECTED MINES IN SOUTH-WEST NIGERIA

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ABSTRACT

Radiation survey aimed at estimating average dose rate in and around companies in Nigeria(Beltec Link and Concord Miners) has been carried out using digital survey meter, RDS-30, calibrated by Technology Finland. The average dose rate was used to estimate annual effective dose of the various categories of workers in the industries. The result of the survey showed that the average dose rate for Concord Miners is 0.70mSv/yr and that of Beltec Link Nig Ltd is 0.60msv/yr which are lower than the occupational dose limit recommended by ICRP (20msv/yr). The annual effective dose for Concord miners is 0.000663mSv and that of Beltec Link Nigeria Ltd is 0.000618mSv.The workers in these companies are not therefore likely to be at serious exposure risk at the present time.

KEYWORDS: Background Radiation, Dose Rate, Effective Dose, Mining, Exposure.

INTRODUCTION

Soil contains radioactivity derived from the rocks which it originated. However, the majority of radioactive elements are chemically bound in the earth crust and are not a source of radiation exposure unless released through natural forces (e.g earthquake or volcanic activities) or human activities (e.g mining or construction). In Nigeria today, prospecting for crude oil is one of the most lucrative activities. Besides crude oil, the next money spinning proceeds from soils are solid minerals in which mining activities are the major works. Generally, only the upper 25 cm of the earth crust is considered a significant source of gamma radiation and artisan mining activities digging up to this layer with the use of digger, shovel and bare hands to scratch and identify the minerals are prevalent. This can results to the exposure of such mining workers. Excluding uranium miners and other workers whose radiation exposure is individually monitored, most of the artisan miners do not have any standard way of monitoring their exposure neither are they careful about it. It could normally be assumed as a hypothesis that the dose rates for the selected mining companies are not high.

There had been various research works carried out in developed countries to monitor limits to ascertain the radiation risk level of workers in the mining industries. However, there seems to be negligible quantity of such work in many developing countries thereby leaving the personnel at risk of exposure. Research works on estimation of dose level in work environments, activities in mining industries are very important, although may be few in some developed countries and very scarce in developing countries. The exposure to high background radiation level in the tin mining area of Jos Plateau, Nigeria has been undertaken by Ademola (2008). The estimation of annual effective dose from natural sources through the ingestion of foodstuffs has been carried out by Jibiri *et al.*, 2007 while Jibiri and Emelue (2008) have investigated soil radionuclide concentration and radiological assessment in and around a refining and petrochemical company in Warri, Niger Delta in Nigeria. Similar researches in other places have been reported. The re-suspension and re-deposition of ^{137}Cs in an urban area: the experience after Goiania accident was reported by Pires Do Rio *et al.* (1994); the calculation of radiation exposure in case of reuse and disposal of NORM waste has also been presented by Dietmar and Roloff (2006). The estimation of dose due to work activities involving naturally occurring radionuclide was investigated by Brandy and Hefner (2008) while the strategies and methods for optimisation of internal exposure of workers from industrial natural sources were presented by Van der Steen and Lefaure (2004). Dose level of occupational exposure in China and also a uniform framework for the management of radiation dose in uranium mining and milling industries were reported by Yuan *et al*. (2007).

The necessity of adequate protection from ionizing radiation necessitate our present focus to estimate the dose rate and the effective dose to workers in the selected mining companies and to compare the results of the study with acceptable standard provided by international bodies. The results will also, provide useful information on exposure status for the selected mining areas. It will further serve as a baseline against which future measurement of dose level of workers in the mining sites and other mining industries in Nigeria may be quantified.

MATERIALS AND METHODS

The two mining companies selected are BELTEC LINK NIG. LTD. AND CONCORD MINERS, all located at Olode Local Government area of Ibadan, Oyo State. The two companies are registered with the government of Nigeria. Olode is about 10.6 miles away from Iwo. The two companies are involved in the mining of BERYL, a hard crystalline mineral, composed of beryllium aluminium silicate that occurs in white, yellow, pink, green, or blue forms and it is used as gems. Due to the work activities that go on continuously at the mining venue, a permanent Identifier (marker) was erected at each of the selected 40 spots around the circumference of the companies. This procedure might result to not having a regular pattern for the collection of data in the selected spots. Hence, readings were taken at a distance of approximately 4.5 meters between two spots; while the starting points were marked by two big trees at the companies. A digital survey meter, RDS-30, calibrated by RADOS Technology in Finland was used to measure the Dose rate at the selected spots. The digital survey meter can detect Gamma and X-rays between the ranges of 48 Kev-1.3 Mev. The dose rate range that can be detected by the survey meter is within the range of 1 μren/hr - 10 rem/hr. The data collection was done for 11 days, which spanned over a period of 6 weeks to allow for variation of the dose from norms and any other sources of radiation in the two companies. The survey meter was placed about the abdominal level and readings were taken when steady. The GPS Garmin e-76 was used to determine the co-ordinates of the spots for future monitoring of the dose rates at the selected companies.

RESULTS AND DISCUSSION

Using a computer programme, the average dose rates per annum, the average dose rate per hour and the average effective dose for all spots in the two companies were calculated. FromTable1 , it can be seen that the average dose rate per annum for Beltec Link Nig Ltd is 0.60 mSv/yr which is lower than the occupational dose limit recommended by ICRP (20 mSv/yr).

From Table 2, the average dose rate/yr for Concord miners for all spots is 0.73 mSv/yr and this is lower than that recommended by ICRP (20 mSv/yr). From Table 3, the average dose rate /hr of Concord miners is 8.29×10^{-5} mSv/hr. The average effective dose for all spots is 0.000663 mSv. It can be seen that the average dose rate/hr of Concord miners (8.29×10^{-5} mSv/hr) is greater than that of Beltec Link Nig Ltd. (6.87×10^{-5} mSv/hr). Similarly the average dose rate/yr of Concord Miners (0.73 mSv/yr) is greater than that of Beltec Link Nig Ltd (0.60 mSv/yr). The reason for this may be due to higher work activities in Concord miners than Beltec Link Nig Ltd which is a newly established company in the local government.

Table 1: Data for Beltic Link Nig. Ltd

Average Dose/ Yr	Occupational dose limit (ICRP)	Stay time of workers	Total number of workers
0.60mSv/yr	20 mSv/yr	9 Hours	30

Table 2: Data for Concord Miners

Average Dose/ Yr	Occupational dose limit (ICRP)	Stay time of workers	Total number of workers
0.73 mSv/yr	20 mSv/yr	8 Hours	20

Comparing the result of the research with that of Ademola (2008) which was calculated as 9.4×10^{-3} mSv/hr carried out in upland region, the values of the dose rate in the two companies (6.87×10^{-5} mSv/h for Beltec and 8.29×10^{-5} mSv/h for concord miners) are seen to be lower. Similarly, the effective dose rate in each of the two companies is less than that of Jibri (2008) which was 0.0352 mSv/yr. The reason for this may be due to the low radionuclide concentrations commonly found in the crude oil and petrochemical area as in our study locations. The research work of Darko *et al.* (2005) reveals that the effective dose per annum for surface mining is 0.26 ± 0.11 mSv and 1.83 ± 0.56 mSv for underground mining. These values are equally higher than the values of the effective dose from our selected mining companies. The explanation for this is simply due to the higher radioactivity in gold mine as in their case. The values of the annual effective dose from the two companies (0.000663 mSv for Beltec Link and 0.000618 mSv for Concord miners) are very much lower to that obtained in the work of Yuan *et al.*(2007) which was reported to be is 5 mSv. Similarly, the values of the annual effective dose are smaller than those of the work of Markus (2008) which has been reported to be between 0.1 mSv - 0.5 mSv. Our investigation then means that mining of solid minerals in areas known to be petroleum rich has the advantage of less risk of exposure to ionizing radiation than those in potentially rocky radioactive mineral containing areas.

Table 3: Average Dose Rate and Annual Effective Dose for Concord Miners

Co-ordinates of Spots	Dose Rates (mSv/hr) ×10^{-5}	Effective Dose (mSv) ×10^{-4}
N070^{0}09'39.0"E 003^{0}57'29.3"	7.66667	6.133
N070^{0}09'39.1"E 003^{0}57'29.1"	7.91667	6.333
N070^{0}09'39.2"E 003^{0}57'28.9"	8.08333	6.467
N070^{0}09'39.2"E 003^{0}57'28.9"	8.16667	6.533
N070^{0}09'39.3"E 003^{0}57'28.7"	7.08333	5.667
N070^{0}09'39.3"E 003^{0}57'28.7"	7.08333	5.667
N070^{0}09'39.4"E 003^{0}57'28.5"	7.25000	5.800
N070^{0}09'39.5"E 003^{0}57'28.4"	7.66667	6.133
N070^{0}09'39.5"E 003^{0}57'28.2"	7.25000	5.800
N070^{0}09'39.6"E 003^{0}57'28.1"	7.50000	6.000
N070^{0}09'39.6"E 003^{0}57'27.9"	7.25000	5.800
N070^{0}09'39.5"E 003^{0}57'27.8"	7.58333	6.067
N070^{0}09'39.2"E 003^{0}57'27.6"	7.25000	5.800
N070^{0}09'39.0"E 003^{0}57'27.6"	7.25000	6.000
+N070^{0}09'38.9"E 003^{0}57'27.6"	7.66667	6.133
N070^{0}09'38.9"E 003^{0}57'27.6"	7.75000	6.200
N070^{0}09'39.0"E 003^{0}57'27.3"	7.83333	6.267
N070^{0}09'38.8Z"E 003^{0}57'27.3"	8.08333	6.467
N070^{0}09'38.8"E 003^{0}57'27.3"	8.33333	6.667
N070^{0}09'38.8"E 003^{0}57'27.2"	8.50000	6.800
N070^{0}09'39.0"E 003^{0}57'27.2"	8.75000	7.000
N070^{0}09'39.8"E 003^{0}57'27.4"	9.34167	7.473
N070^{0}09'39.2"E 003^{0}57'27.1"	9.92500	7.940
N070^{0}09'39.3"E 003^{0}57'26.9"	10.25830	8.207
N070^{0}09'39.4"E 003^{0}57'27.0"	9.84167	7.873
N070^{0}09'39.1"E 003^{0}57'27.6"	9.75833	7.807
N070^{0}09'38.6"E 003^{0}57'29.0"	9.00833	7.207
N070^{0}09'38.5"E 003^{0}57'29.0"	9.00833	7.207
N070^{0}09'38.3"E 003^{0}57'28.9"	9.17500	7.340
N070^{0}09'38.2"E 003^{0}57'28.9"	9.25833	7.407
N070^{0}09'38.0"E 003^{0}57'28.8"	9.34167	7.473
N070^{0}09'38.0"E 003^{0}57'28.6"	9.17500	7.340

Table 3: Cont'd

Co-ordinates of Spots	Dose Rates (mSv/hr) $\times10^{-5}$	Effective Dose (mSv) $\times10^{-4}$
N070^{0}09'38.0"E 003^{0}57'28.5"	8.34167	6.673
N070^{0}09'37.8"E 003^{0}57'28.3"	8.34167	6.673
N070^{0}09'37.7"E 003^{0}57'28.2"	8.42500	6.740
N070^{0}09'37.6"E 003^{0}57'28.1"	8.00833	6.407
N070^{0}09'37.4"E 003^{0}57'28.0"	8.09167	6.473
N070^{0}09'37.3"E 003^{0}57'27.9"	8.17500	6.540
N070^{0}09'37.2"E 003^{0}57'27.8"	8.17500	6.540
N070^{0}09'37.1"E 003^{0}57'27.6"	7.59167	6.073
Average	8.28521	6.628

Table 4: Average Dose Rate and Annual Effective Dose for Beltec Link Nig. Ltd.

Co-ordinates of spots	Dose Rate (mSv/hr) $\times10^{-5}$	Effective Dose (mSv) $\times10^{-4}$
N07011'20.0"E 003^{0}55'38.1"	5.58333	5.025
N07011'20.3"E 003^{0}55'37.8"	5.58333	5.025
N07011'20.4"E 003^{0}55'37.6"	5.66667	5.100
N07011'20.5"E 003^{0}55'37.5"	5.83333	5.250
N07011'20.5"E 003^{0}55'37.3"	5.91667	5.325
N07011'20.5"E 003^{0}55'37.2"	5.91667	5.325
N07011'20.6"E 003^{0}55'37.0"	6.66667	6.000
N07011'20.5"E 003^{0}55'36.9"	6.75000	6.075
N07011'20.5"E 003^{0}55'36.7"	6.91667	6.225
N07011'20.7"E 003^{0}55'36.5"	7.00000	6.300
N07011'20.6"E 003^{0}55'36.4"	7.00000	6.300
N07011'20.5"E 003^{0}55'36.4"	7.08333	6.375
N07011'20.5"E 003^{0}55'36.3"	7.25000	6.525
N07011'20.6"E 003^{0}55'36.8"	7.16667	6.450
N07011'20.6"E 003^{0}55'36.7"	7.08333	6.375
N07011'20.5"E 003^{0}55'37.0"	7.08333	6.375
N07011'20.5"E 003^{0}55'37.0"	7.08333	6.375
N07011'20.6"E 003^{0}55'37.3"	6.58333	5.925
N07011'20.7"E 003^{0}55'37.4"	6.58333	5.925
N07011'20.9"E 003^{0}55'37.5"	6.66667	6.000
N07011'20.7"E 003^{0}55'37.7"	6.75000	6.075
N07011'20.8"E 003^{0}55'37.7"	7.33333	6.600
N07011'20.9"E 003^{0}55'37.7"	7.41667	6.675
N07011'21.0"E 003^{0}55'37.6"	7.41667	6.675
N07011'21.0"E 003^{0}55'37.5"	7.58333	6.825

Table 4: Cont'd

Co-ordinates of spots	Dose Rate (mSv/hr) ×10^{-5}	Effective Dose (mSv) ×10^{-4}
N07011'21.1"E 003^{0}55'37.5"	7.58333	6.825
N07011'21.2"E 003^{0}55'37.3"	7.58333	6.825
N07011'21.2"E 003^{0}55'37.2"	7.66667	6.400
N07011'21.2"E 003^{0}55'37.0"	7.25000	6.525
N07011'21.2"E 003^{0}55'36.9"	7.25000	6.525
N07011'21.2"E 003^{0}55'36.8"	7.33333	6.600
N07011'21.3"E 003^{0}55'36.6"	7.41667	6.675
N07011'21.2"E 003^{0}55'36.4"	7.41667	6.675
N07011'21.1"E 003^{0}55'36.3"	7.41667	6.675
N07011'21.0"E 003^{0}55'36.2"	6.75000	6.075
N07011'20.9"E 003^{0}55'36.1"	6.75000	6.075
N07011'20.8"E 003^{0}55'36.0"	6.75000	6.075
N07011'20.8"E 003^{0}55'35.9"	6.58333	5.925
N07011'20.7"E 003^{0}55'35.8"	6.83333	6.150
N07011'20.6"E 003^{0}55'35.8"	6.25000	5.625
Average	6.86875	6.18188

CONCLUSION

The average dose rate per annum to Concord miners (0.73 mSv/yr) is higher than that of Beltec Link Nig Ltd (0.60 mSv/yr). Similarly the Average does rate (8.29 x 10^{-5} mSv/hr) for Concord miner is higher than that of Beltec Link Nig Ltd (6.87 x 10^{-5} mSv/hr). The average does rates for the two companies are lower than that recommended by ICRP (20 mSv/yr). The annual effective dose for Concord miners is 0.000663 mSv and that of Beltec Link Nigeria Ltd is 0.000618 mSv. This result shows that the workers in the two companies are having very minimal radiation risk from Norms and any other sources of radiation. Work activities in the two companies can therefore be increased through more mechanized system. More workers can be further employed to work in the two companies, thereby creating job opportunities for the unemployed youths in the Olomi local government area of Oyo state. The average does rates in the two selected companies are low certifying less radiation risk and hence workers can spend more time in the companies in order to increase mining activities of the companies which can lead to higher productivity and income. The annual effective doses for the two companies are low, meaning not only less radiation risk to workers in the companies but also its environs where villagers reside.

REFERENCES

Ademola J.A (2008) Exposure to high background radiation level in the tin mining area of Jos Plateau, *Nigeria. J. Radiol. Prot.* 28 ,93-99.

Aleksandra, M., Sonja, I., Vesna, S. and Slobodan, J. (2008). A Dose Estimation for Persons Occupationally Exposed to Ionizing Radiation in Montenegro. *Arch Oncol* 16(1-2), 5-6.

Brandy, A., Hefner, A. (2008). Estimation of Dose Due to Work Activities Involving Materials Containing Naturally Occurring Radionuclides. Australian Standard Institute.

Darko, E. O., Tetteh, G. K. and Akaho, E. H. (2005). Occupational Radiation Exposure to Norms in a Gold Mine. *Radiat Prot Dosimetry*. 114(4): 538-45.

Dietmar, W., Rolf, R. (2006). Method for Calculation of Radiation Exposure in case of Re-use and Disposal of NORM Waste.

International Commission on Radiation Protection (2009). Guidance for Occupational Exposure. Radiation Event Medical Treatment page 1. Retrieved 12 Dec, 2009, from http://www.remm.nlm.gov/ICRP guidelines.htm.

Jibiri, N. N., Farai, P. and Alausa, S. K. (2007). Estimation of Annual Effective Dose due to Natural Radioactive Elements in Ingestion of Foodstuffs in tin Mining Area of Jos-Plateau, Nigeria. *Journal of Environmental Radioactivity*. Vol. 93. 31-40.

Jibiri, N. N and Emelue, H. U. (2008). Soil Radionuclide concentration and Radiological Assessment in and around a Refining and Petrochemical Company in Warri, Niger Delta Nigeria. *J. Radiol Prot* 28: 361-368.

Markus, Z. (2008). Silicas, healing earth / radionuclides.Cant Lab Bs 7-12. Retrived Jun8, 2009 from kantonslaborbs.ch/content.cfm?

Pires Do Rio, M. A., Amaral, E. C. S. and Paretzke, H. G. (1994). The Resuspension and Redeposition of 137Cs in an Urban Area: The Experience after the Goiania Accident. *Journal of Aerosol Science, 25,821-831*.

Van der Steen, J. and Lefaure, C. (2004). Strategies and Methods for Optimisation of Internal Exposure of Workers from Industrial Natural Resources.

Yuan T., Liang'an Z., and Yongjian J.(2007). Dose Level of Occupational Exposure in China *Oxford Journal* 128(4) 491-495.