ISSN NO. 2320-5407

Journal homepage: http://www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH

RESEARCH ARTICLE

MEASUREMENTS OF NATURAL RADIOACTIVITY IN EGYPTIAN DIFFERENT UNDERGROUND PHOSPHATE MINES

A. E. Ali

Physics Department, Faculty of Science EL-Minia University, EL- Minia, Egypt

Manuscript Info

Manuscript History:

Received: 15 August 20115
Final Accepted: 26 September 2015
Published Online: October 2015

Key words:

Life cycle assessment, Life cycle inventory, Environmental data,LCI development framework

***Corresponding Author**

A. E. Ali

Abstract

In addition to the workers in uranium mines, the staff of other underground mines, such as workers to underground phosphate mines, can be exposed in ^{222}Rn and its progeny, In this study the individual radon progeny concentrations were measured in three Egyptian underground phosphate mines to estimate the occupational exposure of the workers at those sites. A filter method was used to measure individual radon progeny concentrations (^{218}Po, ^{214}Pb, and ^{214}Po). The reported mean values of radon progeny concentrations exceed the action levels which are recommended by ICRP 65 (1993). Based on the measured individual radon progeny concentrations (^{218}Po, ^{214}Pb and ^{214}Po) in these mines, the annual effective dose for the workers has been calculated using the lung dose model of ICRP 66 (1994). According to the obtained results, some concentrations were recommended in this study to minimize these exposure levels.

INTRODUCTION

Epidemiological studies on health effects from exposures to radon progeny have been conducted in pyrite, phosphate, fluorspar and shale-clay mines. Although the concentrations of radon progeny in non-metal mines are usually lower than those in metal mines, radon progeny and the associated lung cancer risk should be considered when evaluating the health risks of any miner(1). Such investigations on uranium and other underground miners provided extensive and consistent data on the quantitative risk of lung cancer associated with their exposure(2-6).

Occupational exposures were reviewed in the UNSCEAR (1982) report (7). In which also a number of recommendations were made with regard to data analyses to obtain much clearer indications of occupational exposure in all areas of work, not only to workers in uranium and coal mines. In Egypt, radiation levels in some uranium mines have been investigated. In El-Missikat mine, during 1987, radon progeny concentrations ranged from 444 to 5550 Bq.m^{-3}, while in 1988 these measurement readings ranged from 5180 to 20,720 Bq.m^{-3}. In the Erediya mine, the radon progeny concentrations were between 310 and 8880 Bq.m^{-3} in 1987: in 1988, these levels increased to 8362 to 23,014 Bq.m^{-3} . The increasing of radon progeny concentrations in both mines from 1987 to 1988, may be attributed to the reconstruction of these mines from time to time (more tunnels were opened). During the period 1985-1990, measurements of radon and radon progeny concentrations have been performed for some galleries in the Eastern Desert of Egypt (9). At present, mines of Egyptian underground phosphate mines are not considered as radiation exposed workers. Therefore, the main goal of this study was to determine the occupational radiation exposures due to the individual radon progeny by measuring their concentrations in these mines and to estimate the total annual effective dose for these workers.

MATERIALS AND METHODS

The main phosphate mines in Egypt are located in the Eastern Desert about 500 km south of Cairo. The three regions of Safaga, Hamraween and El-Quser are considered as the main producing regions. They are located within a distance of about 80 km and their depths range from 10 to 50m. The south mine, B mine and Youns C mine were selected to represent Safaga, Hamraween and El-Quser regions, respectively. In each mine about 25 representative sampling sites were selected along the main gallery of the mine and at locations where the ore is mined. In general, the tunnels were about 1.5m wide and about 2m high. At each sampling site five measurements were always made, two near the walls about 1 m above ground and three in the middle of the tunnel at three different positions. For measurements of ^{218}Po, ^{214}Pb and ^{214}Po concentrations, in principle the Tsivoglou method (10) was used. Air samples were collected for 5 min at a flow rate between 5 and 10 l.min^{-1} on a high efficiency filter paper Millipore (Type SM with 2.5 cm in diameter), followed immediately by a sequence of these alpha counts in a 30 min interval. The filter papers were counted using counting system type EDA by placing the filter paper on a scintillation tray coated by silver-activated zinc sulphide. The Pylon RN-190 radon progeny standard source was used for calibration to determine the counting efficiency of the scintillation tray. It houses a dry ^{226}Ra source, which emanates radon gas into a sealed chamber. The radon gas decays into its progeny which deposit on the inner surface of the chamber and on an enclosed filter paper. The RN-190 is designed such that the radon progeny are deposited uniformly over the filter and the chamber surface with an activity deposition of 73.16 Bq.cm-2 ± 4%. The alpha count rate was measured after 5, 15 and 30 min. The measurement of activity concentration is associated with a statistical uncertainty characterized here by standard deviation. The concentrations of ^{218}Po, ^{214}Pb and ^{214}Po were calculated by the following equation [(11)]:

$$C_1 = \frac{37}{vE}\left(0.5945A_5 + 0.8509A_{30} - 1.347A_{15}\right)$$

$$C_2 = \frac{37}{vE}\left(0.3598A_{30} + 0.1485A_{15} - 0.0448A_5\right)$$

$$C_3 = \frac{37}{vE}\left(0.3997A_{15} - 0.3246A_{30} - 0.0293A_5\right)$$

Where:

C_1 = ^{218}Po concentration in Bq m^{-3}
C_2 = ^{214}Pb concentration in Bq.m^{-3}
C_3 = ^{214}Po (= ^{214}Bi) concentration in Bq.m^{-3}

E = counting efficiency
V = volumetric sampling rate in 1.min^{-1}
A_T = total alpha activity at time T after the end of sampling (in count.min^{-1})

DOSE CALCULATIONS

Many investigations have been carried out on the exposure-dose equivalent relationship for radon and its progeny[(12-15)]. These investigations show that many factors affect the dose to the respiratory tract from radon progeny.

It can be estimated the total effective dose through the human lung due to the present measurements in the mines of interest is as follows, based on the values of the activity median aerodynamic diameter 0.25 µm and standard deviation 2.5 which is recommended by ICRP66[(16).] The total deposition has been carried out assuming that the tidal volume and respiratory frequency are given by 1920 ml and 26 min^{-1}, respectively[(16)] Consequently, the ventilation rate is taken 3 m^{-3} .h^{-1}. Moreover, the fraction 0.5 breathed through the nose was used. The obtained values of total deposition and the present measurement of activity concentrations have been substituted into a LUDEP 1.0 personal computer program RPB-SR 264[(17)] to calculate the annual effective dose through the human lung. It is assumed that the workers spent 2000 hours per year at work.

RESULTS AND DISCUSSION

The distribution of individual radon progeny concentrations among the different sampling sites in south mine of Safaga region are plotted in Figure 1. Sampling site No 1 has the lowest 'radon progeny concentration' values while the higher levels were found at sampling site No 6. The values of C_1, C_2 and C_3 in Bq.m-1 were in the ranges 3215 - 5890, 2181- 4037 and 689 – 3313 with an average of 4340 ± 417, 3092 ± 259 and 1720 ± 430, respectively.
The individual radon progeny concentrations values in B mine of Hamraween region are shown in Figure 2. The maximum values were found at sampling site No 4 (deepest point), while the minimum values were found at both sampling site No 1 and No 9 (near to the entrances). The values of the C_1, C_2 and C_3 were in the ranges 1292 – 4503, 879 – 3733 with an average 2743 ± 324, 2178 ± 284 and 1322 ± 268, respectively. Figure 3 shows the measured values of the C_1, C_2 and C_3 in Youns C mine of El-Quser region. The maximum values were found at sampling point No 6 (deepest point) where the 'ore' is extracted, while the minimum values were found at sampling point No 1, at the mine entrance. These values were within the following ranges 656 – 3448, 360 – 2297 and 221 – 1685 with arithmetic means of 1929 ± 506, 1354 ± 365 and 983 ± 277, respectively.
In general, the mean values of the radon progeny concentrations in all mines of interest significantly exceed the action level for working places which is recommended by ICRP 65[(18)] . The measurement of radon progeny concentrations in three mines is listed in Table 1. In the south mine, the maximum values of these concentrations were higher than those of both B and Youns C mines, due to poorer ventilation in the first one. The annual effective dose due to the inhaled individual radon progeny (^{218}Po, ^{214}Pb and ^{214}Po) for the miners are shown in Table 2. It can be seen that the dose from 218Po was higher than that from 214Pb and 214Po in all mines. In general, the present calculated dose exceeded the dose limit 20 mSv.y-1 (averaged over a period of 5 years with the proviso that the effective dose should not exceed 50 mSv in any single year) as recommended by ICRP 60[(19)] .

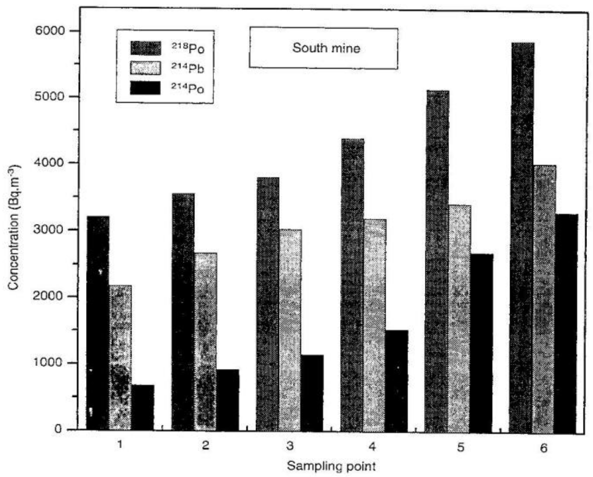

Figure 1. Radon progeny concentrations in South mine (Safaga region).

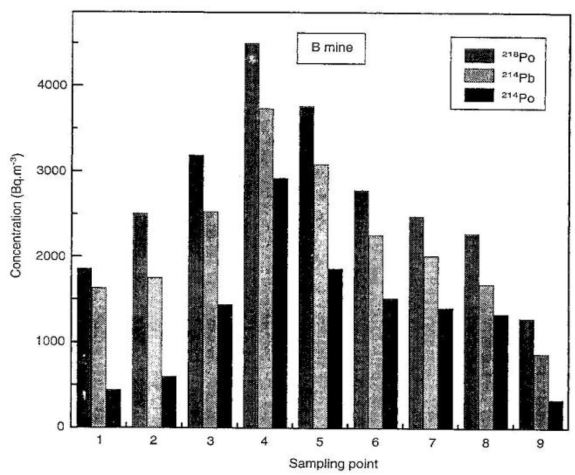

Figure 2. Radon progeny concentrations in B mine (Hamraween region).

Table 1. The measurement of radon progeny concentrations in South mine, B mine and Youns C mine.

Mine	Sampling point	Radon progeny concentration ($Bq.m^{-3}$)		
		^{218}Po	^{214}Pb	^{214}Po
South mine (Safaga region)	1	5890	3436	3312
	2	5157	3401	2705
	3	3714	3528	1390
	4	3762	3423	1536
	5	4003	3336	1151
	6	4003	2776	1151
	7	3811	2180	688
B mine (Hamraween region)	1	1859	1636	422
	2	2513	1755	601
	3	3192	2534	1444
	4	4502	3733	2928
	5	3765	3096	1868
	6	2793	2262	1523
	7	2488	2019	1413
	8	2285	1690	1341
	9	1291	878	341
Youns C mine (El Quser region)	1	656	360	220
	2	723	466	291
	3	1176	875	616
	4	2423	1838	1597
	5	3150	2291	1488
	6	3447	2296	1684

Table 2. The calculated effective dose for workers in South mine, B mine and Youns C mine due to inhaled radon progeny (^{218}Po, ^{214}Pb and ^{214}Po).

Mine	Annual effective dose ($mSv.y^{-1}$)		
	^{218}Po	^{214}Pb	^{214}Po
South mine (Safaga region)	182	1.26	2.37×10^{-4}
B mine (Hamraween region)	139	1.16	2.09×10^{-4}
Youns C mine (El Quser region)	107	0.71	1.2×10^{-4}

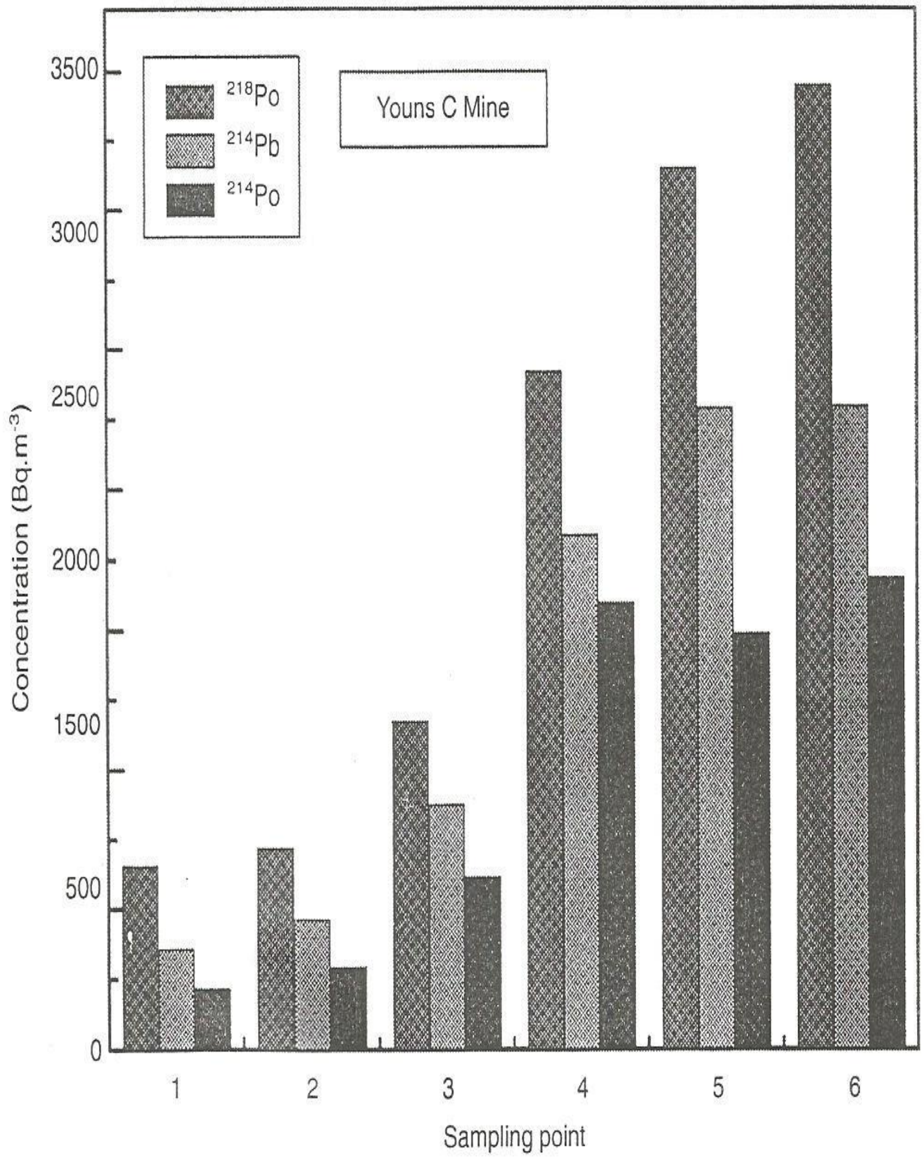

Figure 3. Radon progeny concentrations in Youns C mine (El Quser region).

REFERENCES

1. Axelson, O Occupational and Environmental Exposures to Radon Risks. Ann. Rev. Public Health 12, 255 (1991).
2. National Research Council (NRC). Health Risks of Radon and Other Internally Deposited Alpha-Emitters. BEIR IV (Washington, DC: National Academy Press) (1988).
3. Kunz., E., Seve, J., Placek , V. and Horacek, J. Lung Cancer in Man in Relation to Different Time Distribution of Radiation Exposure. Health Phys. 36, 699-706 (1979).
4. Howe, G. R., Nair, R. C., Newcompe, H. B., Miller, A. B., Burch, J. D. and Abbatt J. D. Lung Cancer Mortality (1950-1980) in Relation to Radon Daughter Exposure in a Cohort of Workers at the Eldorado Port Radium Min: Possible Modification of Risk by Exposure Rate. J. Natl. Cancer Inst. 79. 1255-1260 (1987).
5. Samet, J. M., Pathak, D. R., Morgan, M. V., Key, C. R., Valdivia, A. A.and Lubin Cancer Mortality and Exposure to Rn Progeny in a Cohort of New-Mexico Underground U Miners. Health Phys. 61, 745-752 (1991).
6. Tirmarch, M., Raphalen, A., Allin, F., Chameaud, J. and Bredon, P.Mortality of a Cohort of French Uranium Miners Exposed to Relatively Low Radon Concentrations. Br. J. Cancer 67, 1090-1097 (1993).
7. United Nation Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). Sources and Effects of Ionizing Radiation (New York: United Nations) (1988).
8. Hussin, M. I., El Naggar, A. M. and Saied, A. F. Measurements of Radiation Levels in some Uranium Tunnels in Egypt. In: Proc. First Arab Conf. on Biophysics, 28-30 Nov., Cairo (1988).
9. Abdel Monem, A. A., Hussein, M. I., EI Naggar, A. M., Attia K. E. and Omar, S. M. Monitoring of Radon Gas and Daughters in Uranium Exploration Mines, Eastern Desert, Egypt. In: Proc. Regional Symp. On Environmental Studies, p. 507 (1990).
10. Tsivoglou, E. C., Ayer, H. E. and Holaday, D. A. Occurrence of Nonequilibrium Atmospheric Mixtures of Radon and its Daughters in Air, Nucleonics 11, 40 (1953).
11. Thomas, J. W. Determination of Radon Progeny in Air From Alpha Activity of Air Samples. Health Phys. 23. 783 (1972).
12. Reineking, A., Butterweek, G., Kesten, J. and Porstendorfer, J. Unattached Fraction and Size Distribution of Aerosol-Attached Radon and Thoron Daughters in Realistic Living Atmospheres and Their Influence on Radiation Dose. In: Proc. Twenty-Ninth Hanford Symp. On Health and the Environmental-Indoor Radon and Lung Cancer: Reality or Myth (Richland, WA Pacific Northwest Laboratory) pp. 129-146 (1992).
13. Zock, C., Porstendofer, J, and Reineking, A. The Influence of Biological and Aerosol Parameters of Inhaled Short-Lived Radon Decay Products on Human Lung Dose. Radiat. Prot. Dosim. 63. 197 (1996).
14. El-Hussein, A., Ahmed, A. A. and Mohamed, Radiation Dose to the Human Respiratory Tract From Inhalation of Radon- 222 and its progeny , App. Radiat. Isot. 49(47), 783-790 (1998).
15. Mohamed, A., El-Hussein, A. and Ali, A. E. Measurements of Thorium-B(212Pb) in Outdoor Environment and Evaluation of Equivalent Dose. J. Environ. Radioact. 49, 181-193 (200).
16. International Commission on Radiological Protection. Human Respiratory Tract Model for Radiological Protection. ICRP Publication 66 (oxford: Pergamon) (1994).
17. NRPB-SR264. LUDER 1.0 Personal Computer Program for Calculating Internal Doses using the ICRP Respiratory Tract Model (Richland, WA, USA: Pacific Northwest Laboratory) (1993).
18. International Commission on Radiological Protection. Protection against Radon-222 at Home and at work. ICRP Publication 65 (Oxford: Pergamon Press) (1993).
19. International Commission on Radiological Protection. 1990 Recommendations of the International Commission on Radiological Protection. ICRP Publication 65 (Oxford: Pergamon Press) (1991).