INTERNATIONAL JOURNAL OF ENGINEERING AND MANAGEMENT SCIENCES

www.scienceandnature.org

RADIUM CONTENT AND RADON EXHALATION RATES IN SOME SOIL SAMPLES OF ADIGUDEM, ETHIOPIA

Nigus Alene Assefa & Bhardwaj M.K.
Department of Physics, College of Natural and Computational Sciences, Mekelle University, Tigray Region, Ethiopia.

ABSTRACT
In the present work Eleven soil samples were collected from the area within two kilometer Adigudem City, Tigray Region, Ethiopia.. Solid state nuclear track detectors (LR-115 type II) have been used to measure the effective radium content in soil at Adigudem City. Etching was done with 2.5 N NaOH and optical microscope was used with the purpose of counting of alpha particle tracks. Results obtained shows that the values of effective radium content vary from 10.75 to 42 $Bq.kg^{-1}$ with a mean value of 25.9 $Bq.kg^{-1}$ and standard deviation of 9.81$Bqkg^{-1}$. Radium concentration has been found within the safe limit as recommended by a group of experts of the OECD. The results reveal that the area is safe as far as the health hazards due to radium content and radon exhalation rate.

KEYWORDS: Soil, plastic track detectors, Optical Microscope, Etching, radium concentration, radon exhalation rates.

INTRODUCTION

Radium is a radioactive element that occurs naturally in the earth's crust. Radium in its pure form is a silvery-white heavy metal that oxidizes immediately upon exposure to air. Radium has a density about one half that of lead and exists in nature mainly as radium-226, although several additional isotopes are present [1]. Radon, a gaseous product of radium, is odorless, colorless and tasteless. Soil is the prime source of uranium and it is used as the building materials. As a result radon reaches us through these building materials. Radon (^{222}Rn) is a decay product of radium (^{226}Ra) which decays after completing its half-life (3.83 days) directly into its progeny. Radon varies in different quantities in different materials and place to place, because radon is chemically un-reactive, it freely moves between particles of building materials (like soil, rock and sand etc) to the soil surface [2]. Radon has carcinogenic effect, in fact; it is the first known cause of lung cancer among nonsmokers [3,4]. In the present work "Sealed Can Technique" is used by using LR-115 type II plastic track detectors. The radon exhalation rate and radium is being measured for the first time in Adigudem, Ethiopia according to the best of our knowledge. The motivation of work is to measure radiological health risk level of radon exhalation rates and radium in this area. A distance of 24 km had been covered in this study performed.

Description of the Study Area

The study area, Adigudem, is located in south eastern part of Tigray. Adigudom town is the capital city of Wereda Hintalo Wajerat. It is 37 km south of Mekelle city and 746 km from Addis Abeba with location of latitude $13^{0}14'50"$N, and longitude $39^{0}30'53"$E.

The climate of the area is extremely cold in summer and very hot in winter. Three types of soils have been found which are

- Clay
- Sand
- Silt

Figure 1: Description of the study area

MATERIALS AND METHODS

Eleven soil samples were collected from different places of urban area of Adigudem town by grab sampling method. Sealed Can technique has been used. Soil samples were dried in an oven at 110ºC for three hours and then dried samples were grinded and sieved in a 200 mesh sieve.150gm of fine powder of soil sample was placed at the bottom of a Cylindrical can of size 7 cm x 10 cm and kept sealed for a period of three weeks to get equilibrium between radium and radon progeny. After that the top of can was fitted with 2.5cm x 2.5 cm size of LR-115 plastic track detector and can was left sealed for a period of one month's Detectors were washed with distilled water properly. The tracks were observed and counted by using microscope with a magnification of 400x.The radium concentrations were found by using this formula [5]:

$$C_{Ra}\left(Bq.kg^{-1}\right)=\left(\frac{\circ}{KT_e}\right)\left(\frac{hA}{M}\right)$$

Where M (M=0.150) is the mass of the soil sample in kg, A (A=3.85x10^{-3}) is the area of cross-section of the can in m^2; h is the distance between the detector and top of the solid sample in meter. The mass exhalation rate of the sample for release of the radon can be calculated by using the expression[5]:

$$E_x(M)\left(Bq.kg^{-1}.d^{-1}\right)=C_{Ra}\left(\frac{a_{Ra}}{a_{Rn}}\right)\frac{1}{T_e}$$

The surface exhalation rate of the sample for release of radon can be calculated by using the expression [5];

$$E_x(S)\left(Bq.m^{-2}.d^{-1}\right)=\left[C_{Ra}\left(\frac{a_{Ra}}{a_{Rn}}\right)\frac{1}{T_e}\right]\frac{M}{A}$$

RESULTS AND DISCUSSION

The values of radon exhalation rate in terms of area and mass and radium in soil samples from Adigudem, Ethiopia, are depicted in table 1. It is clear from the table that the values of effective radium content vary from 10.75 to 42 Bq.kg^{-1} with a mean value of 25.9 Bq.kg^{-1} and standard deviation of 9.81 Bqkg^{-1}. The table also presents the value of mass exhalation and surface exhalation rates of radon of soil samples. The mass exhalation rate has been found to vary from 0.29 x 10^{-5} to 1.13x10^{-5} Bq.kg^{-1}.d^{-1} with a mean value of 0.7x10^{-5} Bq.kg^{-1}.d^{-1} and standard deviation of 0.26x10^{-5} Bq.kg^{-1}.d^{-1} The surface exhalation rate has been found to vary from 11.30 x 10^{-5} to 44.03 x 10^{-5} Bq.m^{-2}.d^{-1}with a mean value of 27.1 x 10^{-5} Bq.m^{-2}.d^{-1} and standard deviation of 10.21 x 10^{-5} Bq.m^{-2}.d^{-1}. The values of effective radium content are less than the permissible value of 370 Bq.kg^{-1} as Recommended by Organization for Economic Cooperation and Development. Hence, the result shows that this urban area is safe as for as the health hazards of radium is concerned. And soil may be used with purpose of construction of houses.

RESULTS AND DISCUSSION

The values of radon exhalation rate in terms of area and mass and radium in soil samples from Adigudem, Ethiopia, are depicted in table 1. It is clear from the table that the values of effective radium content vary from 10.75 to 42 $Bq.kg^{-1}$ with a mean value of 25.9 $Bq.kg^{-1}$ and standard deviation of 9.81 $Bqkg^{-1}$. The table also presents the value of mass exhalation and surface exhalation rates of radon of soil samples. The mass exhalation rate has been found to vary from 0.29×10^{-5} to 1.13×10^{-5} $Bq.kg^{-1}.d^{-1}$ with a mean value of 0.7×10^{-5} $Bq.kg^{-1}.d^{-1}$ and standard deviation of 0.26×10^{-5} $Bq.kg^{-1}.d^{-1}$ The surface exhalation rate has been found to vary from 11.30×10^{-5} to 44.03×10^{-5} $Bq.m^{-2}.d^{-1}$with a mean value of 27.1×10^{-5} $Bq.m^{-2}.d^{-1}$ and standard deviation of 10.21×10^{-5} $Bq.m^{-2}.d^{-1}$. The values of effective radium content are less than the permissible value of 370 $Bq.kg^{-1}$ as Recommended by Organization for Economic Cooperation and Development. Hence, the result shows that this urban area is safe as for as the health hazards of radium is concerned. And soil may be used with purpose of construction of houses.

CONCLUSION

1. It is concluded from our measurements that the Radon concentration in soil air varies considerably and the kind of soil plays an important role. With the help of the table given below we conclude the clay type soil has more concentration of radon than the silt type soil and silt type soil has more radon concentration than sand.
2. Radium concentration has been found below the safe limit of 370 Bq/Kg as recommended by a group of experts of the Organization for Economic Cooperation and Development (OECD). So, it is concluded that the area is safe as far as the health hazards due to radium and radon exhalation rate.

S.No.	Sample code	Soil type	P (track density)	C_{Ra}	$E_x(M)x10^{-5}$	$E_x(S)x10^{-5}$
1	S-06	Sand	4,640	19.49	0.52	20.26
2	S-08	Clay	8,208	34.47	0.92	35.84
3	S-03	Sand	3,968	16.67	0.45	17.53
4	S-05	Silt	6,176	25.94	0.70	27.27
5	S-07	Clay	10,000	42	1.13	44.03
6	S-04	Sand	2,560	10.75	0.29	11.30
7	S-09	Sand	5,392	22.65	0.61	23.77
8	S-01	Clay	7,520	31.58	0.85	33.12
9	S-11	Sand	3,264	13.71	0.37	14.42
10	S-02	Clay	9,280	38.98	1.04	40.52
11	S-10	Silt	6,800	28.56	0.77	30.00
			Maximum	42	1.13	44.03
			Minimum	10.75	0.29	11.30
			Mean	25.9	0.7	27.1
			S.D	9.81	0.26	10.21

Table 1: The values of radium concentration and radon exhalation rates in soil samples of Adigudem

ACKNOWLEDGMENT
Authors are thankful to Habtu Alemayehu Atsbaha (Ph.D), Dean College of Natural and Computational Sciences, and to Tadele Hadush Abriha (MSc), Head department of physics Mekelle University, Mekelle, Tigray Region, Ethiopia for providing the facilities to carry out this work.

REFERENCES

[1] Argonne National Laboratory, EVS Human Health Fact Sheet, August 2005

[2] Singh AK (1988) Uranium and radon studies using track etch detector. Ph. D Thesis, Aligarh Muslim University, Aligarh. India.

[3] US Environmental Protection Agency (2004) A citizen's guide to radon; fourth edition Washington DC; US Government Printing office; 402-K02-006.

[4] Singh BP, Pandit B, Bhardwaj V N, Paramjit Singh , Rajesh Kumar (2010). Study of radium and radon exhalation rate in some solid samples using solid state nuclear track detectors. *Indian Journal of Pure and Applied Physics, 48: 493 – 495.*

[5] Shakir, M., Ameer Azam, Naqvi, A. H., Verma Deepak, Zubair, M., Bhardwaj, M. K. (2010) Recent trends in radiation physics research ISBN 978-81-7906-227-2 pp.356-357.

[6] U.S. Environmental Protection Agency, December 1990

[7] James E.Martin, Physics For Radiation protection, Second Edition,2006

[8] Audeem W. Fentiman, Brian K. Hajek, Joyce E. Meredith., OHIO State University, What Are the Sources of Ionizing Radiation? RER-22

[9] Weast, R. C., and M. J. Astle, 1981. CRC Handbook of Chemistry and Physics. CRC Press, Boca Raton.

[10] UNSCEAR (United Nations Scientific Committee on the Effects of Atomic Radiation) (1993), "Sources and effects of ionizing radiation", United Nations ed., New York, E.94.IX.2.

[11] Schumann, R. and L. Gundersen. 1996. Geological and climatic controls on the radon emanation coefficient. Environment International, 22 (Suppl 1): S439-S446.

[12] Semkow, T. 1990. Recoil-emanation theory applied to radon release from mineral grains. Geochimica et Cosmochimica, 54: 425-440.

[13] Misdaq, M.A., H. Khajmi and A. Ktata. 1998. Study of the influence of porosity on the radon emanation coefficient in different building material samples by combining the SSNTD technique with Monte Carlo simulations. Radiation Physics and Chemistry, 53: 385-390.

[14] Markkanen, M. and H.. Arvela. 1992. Radon Emanation from soils. Radiation Protection Dosimetry, 45 (1): 269-272.

[15] Amin, Y., R. Mahat, S. Doraisamy and S. Subramaniam. 1995. The effect of grain size on the radon emanation rate. Applied Radiation and Isotopes,46 (6/7): 621-622.

[16] Sun, H. and D. Furbish. 1995. Moisture content effect on radon emanation in porous media. Journal of Contaminant Hydrology, 18: 239-255.

[17] Stranden, E., A. Kolstad and B. Lind. 1984. Radon exhalation: Moisture and temperature dependence. Health physics, 47 (3): 480-484.

[18] Sabol, J. and Weng, P.-S. (1995). Introduction to radiation protection dosimetry. World Scientific,Singapor