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MEASUREMENT OF RADIUM CONTENT AND RADON EXHALATION RATES IN SOIL SAMPLES OF MEKELLE CITY, ETHIOPIA

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ABSTRACT

In the present work fifteen soil samples were collected from the area within three kilometer around Down Town, Mekelle City, Tigray Region, Ethiopia. Sealed can technique' using LR-115 type -2 plastic track detector strippable has been used in order to measure effective radium content, radon mass exhalation rates and radon surface exhalation rates. Etching was done with 2.5 N NaOH and optical microscope was used with the purpose of counting of alpha particle tracks. The values of effective radium content are found to range from 11.56 to 312.83 $Bq.Kg^{-1}$ with the mean value of 162.19 $Bq.Kg^{-1}$ which are lower than the permitted value of 370 $Bq.Kg^{-1}$ as recommended by Organization for Economic Cooperation and Development (OECD). The values of mass exhalation rates are found to range from 0.14×10^{-5} to 3.71×10^{-5} $Bq. Kg^{-1}.d^{-1}$ with the mean value of 1.93 $Bq.Kg^{-1} d^{-1}$ while the values of surface exhalation rates are found to range from 3.55×10^{-5} to 96.49×10^{-5} $Bq.m^{-2}d^{-1}$ with the mean value of 50.02 $Bq. m^{-2} d^{-1}$.

KEYWORDS: Radium Content, Radon Exhalation Rates, LR -115 Plastic Track detector type -2 strippable , Etching, Optical Microscope.

INTRODUCTION

The naturally occurring radio nuclides like U^{238}, Ra^{226}, Th^{232} and K^{40} present in the soil causes health hazards externally due their gamma ray emission and internally due inhalation of radon and its progeny[1]. Radon is a densest noble, radioactive ($T_{1/2}$ = 3.823 days), colorless, odorless gas. When it cooled below its freezing point of 202 K it emits brilliant phosphorescence that turns from yellow to orange red as the temperature lowers. Radon is a largest source of radiation exposure to human. Enhanced level of it causes the health hazards like respiratory functional changes and occurrence of lung cancer[2-4,10]. Radon is the decay product of radium. Radium present in the soil is taken by the plants and enters into the body with vegetarian/ non-vegetarian food and tends to follow calcium metabolic process[9] to become concentrated in bones. The radiation given off by radium bombards bone marrow and destroys tissues that produce red blood cells[5]. By knowing the radium content in the soil consequently the radon exhalation rates we may know that the area is safe as far as the health hazards or not. In the present work track etch Sealed Can Technique (cans fitted with LR-115 type -2 plastic track detector) has been used to measure radium content present in the soil collected from the area within three Kilometers around Down Town, Mekelle, Tigray Region, Ethiopia. Radon surface and mass exhalation rates are also studied.

Study Area

Mekelle is a city in the Northern Tigray Region of Ethiopia. It is located some 780 Km north of capital Addis Ababa at a latitude and longitude of $13^{0}29'$ N $39^{0}29'$ E with an elevation of 2084 meters above sea level. Adminiratively, Mekelle is considered as a special zone.

Formulation

Effective radium content in the soil samples of study area were calculated by using following formula [5,9]

$$C_{Ra}(Bq./Kg) = (\rho/KT_e)\ (h\ A/M)$$

Where ρ is the track density measured in tracks cm^{-2}, K is the sensitivity factor, h is the distance in meters between the top of soil and detector fitted in can, M is the mass of soil in Kg, A is area of cross-section of cylindrical can measured in m^2 and T_e is the effective exposure time given as [5,9]

$$T_e = [\ T - \frac{\ \ }{\ \ }(1 - \qquad)]$$

Where λ_{Rn} is the decay constant of radon and T is the exposure time (60 days)

Radon exhalation rates in terms of mass (E_m) and surface area exhalation rates(E_s) were calculated using following relations [9]

$$E_m = C_{Ra}\,(\lambda_{Ra}\,/\,\lambda_{Rn})\ (1/T_e)$$

Where λ_{Ra} is the decay constant of radium. E_m has been measured in $Bq.Kg^{-1}\ d^{-1}$ and

$$E_s = C_{Ra}\,(\lambda_{Ra}\,/\,\lambda_{Rn})\ (1/\ T_e\ )\ (M/A)$$

$$= E_m\ x(M/A)$$

E_s has been measured in $Bq.m^{-2}d^{-1}$.

EXPERIMENTAL TECHNIQUES

Radium content and radon exhalation rates in the soil samples of study area were measured by following the sealed can technique [5-9]. Soil samples were dried in an oven at $120^{\circ}C$ for two hours and then dried samples were grinded and sieved in a 200 mesh sieve.100 gm 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 four 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 two months. Detector recorded the tracks of alpha particles emitting from radon gas which was produced by alpha decay of radium. Exposed detectors were retrieved from top inner surface of can and were etched with 2.5N NaOH at $60^{\circ}C$ [5, 9, 11, 12] for 75 minutes to reveal the alpha tracks. Etching was done to reduce the thickness of detector, also, to about 5 micrometer [9,16] as the tracks of less depth are possible due to alpha particles coming from the other sources. Detectors were washed with distilled water properly. Tracks of alpha particle on detectors were counted using optical microscope at a magnification of 400x

RESULTS AND DISCUSSION

The values of effective radium content, mass exhalation rates and surface exhalation rates in the soil samples collected from area within three kilometers around Down Town, Mekelle city, Tigray Region, Ethiopia are depicted in table -1.

TABLE – 1. Effective radium content, surface exhalation rates ,mass exhalation rates in soil samples of Mekelle city.

S.No.	Sample No.	Effective radium content $(Bq.Kg^{-1})$	Surface exhalation rates $(Bq.\ m^{-2}d^{-1})\ x\ 10^{-5}$	Mass exhalation rates $(Bq.Kg^{-1}d^{-1})\ x10^{-5}$
1	S-1	11.56	3.55	0.14
2	S-2	16.32	5.03	0.19
3	S-3	18.92	5.84	0.26
4	S-4	70.56	21.76	0.84
5	S-5	82.86	25.56	0.98
6	S-6	112.58	34.72	1.34
7	S-7	152.63	47.08	1.81
8	S-8	161.68	49.87	1.92
9	S-9	191.28	58.99	2.27
10	S-10	210.37	64.88	2.50
11	S-11	251.46	77.56	2.98
12	S-12	266.58	82.22	3.16
13	S-13	278.73	85.97	3.31
14	S-14	294.63	90.87	3.50
15	S-15	312.83	96.49	3.71
		Mean = 162.19	Mean = $50.02x10^{-5}$	Mean = $1.93x10^{-5}$

The values of effective radium content vary from 11.56 to 312.83 $Bq.Kg^{-1}$ with mean value of 162.19$Bq.Kg^{-1}$. These values are lower than the value of 370 $Bq.Kg^{-1}$ as recommended by OECD, 1979 [15]. Among all values of effective radium content sample 15 has highest value .This value of radium content may be attributed to the coal mixed with the soil of sample 15 [13]. It is seen from the table -1 that effective radium content in soil of samples 11,

12, 13 and 14 are little higher than that of the soil of samples 1-10. These higher values may be due to some red small stone pieces mixed with the soil which were grinded [14]. It is also clear from the table -1 that the mass exhalation rates vary from 0.14 $x10^{-5}$ to 3.71 $x10^{-5}$ $Bq.Kg^{-1}$ d^{-1} with mean value of 1.93 $x10^{-5}$ $Bq.Kg.d^{-1}$ while the surface exhalation rates vary from $3.55x10^{-5}$ to 96.49 $x\ 10^{-5}Bq.m^{-2}d^{-1}$ with the mean value of 50.02 $x10^{-5}Bq.m^{-2}d^{-1}$.

The study area is advisable to be used as residential area. These results are reported for the first time with the best of our knowledge.

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