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MEASUREMENT OF RADON CONCENTRATION IN INDOOR AIR IN SOME DWELLINGS OF DEBRE MARKOS, ETHIOPIA

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ABSTRACT
Study of indoor radon has been carried out in some dwellings of Debre Markos, Ethiopia using LR-115 type II plastic track detectors. Radon is naturally occurring radioactive gas and it is a product of the natural radioactive decay of uranium, as found in small quantities in most rocks, soils and water. It can migrate to the atmosphere, where it is inhaled together with the other components of the atmosphere and causes the DNA damage and lung cancer. Values of concentration of radon in Debre Markos, Ethiopia ranges from 98.70 to 392.75 $Bq.m^{-3}$ with an average of 217.01 $Bq.m^{-3}$ and standard deviation 105.55 $Bq.m^{-3}$. The inhalation dose varies from 0.89 to 3.53 $mSv.y^{-1}$ with an average of 1.95 $mSv.y^{-1}$ and standard deviation 0.95 $mSv.y^{-1}$. Stone has been found as the main source of higher radon concentration in few dwellings of the study area i.e Debre Markos, Ethiopia. Radon concentration and inhalation dose in Debre Markos, Ethiopia agree with the action level as recommended by ICRP but it is found higher than the action level as recommended by Environmental Protection Agency (EPA) in few dwellings.

KEYWORDS: Radon concentration; LR-115 type II; Debre Markos, Ethiopia.

INTRODUCTION
Radon is a gas that has no color, odor, or taste and comes from the natural radioactive breakdown of uranium in the ground. As It is chemically inert so present everywhere in the environment. Radon enters into the house through; cracks, construction joints, gaps in floors, gaps around service pipes and cavities inside walls [1] and building construction materials [2]. The outdoor air contributes to the radon concentration indoors via Tap-water and the domestic gas supply is usually radon sources of minor importance with a few exceptions [3]. It is an unstable radionuclide $T_{1/2}$ = 3.82 days that disintegrates through short lived decay products before reaching to the final stable daughter lead. When radon gas is inhaled, densely ionizing alpha particles emitted by deposited short-lived decay products of radon (Po-218 and Po-214) can interact with biological tissue in the lungs leading to DNA damage [4]. The radon is gaseous element but its daughter products Po-218 and Po-214 are solid metallic particles and are attached with the air molecules consequently may be inhaled directly. Not everyone who breathes radon decay products will develop lung cancer. An individual's risk of getting lung cancer from radon depends mostly on three factors: the level of radon, the duration of exposure, and the individual's smoking habits. Risk increases as an individual is exposed to higher levels of radon over a longer period of time. Smoking combined with radon is an especially serious health risk. The risk of dying from lung cancer caused by radon is much greater for smokers than nonsmokers. Children have been reported to have greater risk than adults for certain types of cancer from radiation, because of their lung shape and rate of breathing [5]; and children spend their time mostly in home. The World Health Organization (WHO 1988) [6] recommends simple remedial action for buildings with annual average radon concentration of 200 Bq/m^3, without delay if the radon concentration is higher than 800 Bq/m^3; the same upper bound of 200 Bq/m^3 is recommended for new dwellings (WHO 1987) [7]. The ICRP has recently adopted a new recommendation on "protection against radon at home and at work" (ICRP 1993) [8], in which a range of action level values is proposed for existing dwellings: from (200 to 600 Bq/m^3). Environmental Protection Agency (EPA 1993) recommends the action level of 148 Bq/m^3 (4 pCi/L) [4]. There is no known threshold concentration below which radon exposure presents no risk [9]. Even low concentrations of radon can result in a small increase in the risk of lung cancer. The majority of radon induced lung cancers are caused by low and moderate radon concentrations rather than by high radon concentrations, because in general less people are exposed to high indoor radon concentrations [10].With the aim of health hazards due to radon exposure, in the present work the radon concentration in the 12 dwellings of Debre Markos, Ethiopia has been measured.

MATERIALS AND METHODS
Experimental method for radon detection and measurements are based on alpha particle counting of radon. The plastic track detector (LR-115 type II) which is cellules nitrate film of 12 μm thickness was used to record alpha tracks. Dwellings were selected randomly some dwellings were ventilated and others were unventilated. This plastic track detector film of size 2.5cm × 2.5cm was fixed at 1 m from the roof of the room. LR-115 type II plastic track detector has the property that the primary damage caused in that by the passage of alpha particles remains fixed. This track may be made visible with the

help of etching with 2.5 N NaOH. In the etching procedure, the films of LR-115 type II plastic track detector were kept in 2.5 N NaOH in beaker at 60 ^{0}C for 75 minute. The etched films were washed with distilled water and after that got dried and the formed tracks on LR-115 type II films were counted using polarized light optical microscope at the magnification of 400×. The tracks were counted automatically in 12 different fields around center of the detector (covering 9.9 mm^2). The tracks appeared as dark spots on a clear red background, and grey-level threshold detection was performed to separate the tracks from the clear plastic track detector (LR-115 type II). Few tracks were rejected due to not falling within the acceptance criteria [11]. The use of NaOH was necessary to reduce the thickness of the film and to increase the clarity of the film to count the tracks of the detector.

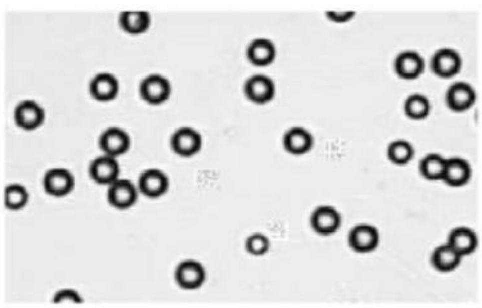

Fig 1: Alpha tracks on the detector

Formulations with the purpose of radon concentration measurement, the radon track density was calculated using the following formula.

$$\rho = \frac{Number\ of tracks}{Total\ area} \quad [1]$$

where ρ is track density

Potential alpha energy concentration (PAEC) has been calculated as following [12]

$$C_p\ (mWL) = \frac{\rho}{KT} \quad [2]$$

where (mWL) is mili working level which is the unit of C_p (PAEC), K is calibration factor between radon and its progeny and T is exposure time in days . And radon concentration has been calculated using the following equation:

$$C_{Rn}(Bq.m^{-3}) = 3.7C_p/F \quad [3]$$

where F =0.4 is the equilibrium factor.

The inhalation dose was calculated in ($mSv.y^{-1}$) using the relation:

$$D_{in}(mSv.y^{-1}) = nC_{Rn} = 0.009C_{Rn}. \quad [4]$$

where n is a constant which equal to 0.009 ($mSv.m^3/Bq.y$).

RESULTS AND DISCUSSION

Table (4.1) shows the values of radon concentration and inhalation dose in some dwellings of Debre Markos, Ethiopia. The values of radon concentration vary from 98.7 to 392.75 $Bq.m^{-3}$ with an average of 217.01 $Bq.m^{-3}$ and standard deviation 105.55 Bq.m−3. The values are found to agree with the action level of 200 $Bq.m^{-3}$ to 600 $Bq.m^{-3}$ as recommended by International Commission of Radon Protection (ICRP) [6]. The values of inhalation dose vary from 0.89 to 3.53 $mSv.y^{-1}$ with an average of 1.95 $mSv.y^{-1}$ and standard deviation 0.95 $mSv.y^{-1}$. These values are also found to agree with international recommended value of (3-10 $mSv.y^{-1}$) [6] i.e action level.

No	Location	$\rho(tracks/cm^2)$	$C_p(mWL)$	$C_{Rn}\ (Bq.m^{-3})$	$D_{in}(mSv.y^{-1})$
1	Room	371.50	10.67	98.70	0.89
2	Room	715.00	20.55	190.09	1.71
3	Room	687.25	19.75	182.69	1.64
4	Room	481.50	13.84	128.02	1.15
5	Office	1144.50	32.89	304.23	2.74
6	Room	1198.25	34.43	318.48	2.87
7	Room	1477.75	42.46	392.75	3.53
8	Room	564.75	16.23	150.13	1.35
9	Room	590.50	16.95	156.79	1.41
10	School	1451.00	41.69	385.63	3.47
11	Office	390.00	11.21	103.69	0.93
12	1^{st} *floor*	726.00	20.86	192.95	1.74

Table 1: Radon concentration, potential alpha energy concentration, track density and inhalation dose in some dwellings of Debre Markos, Ethiopia.

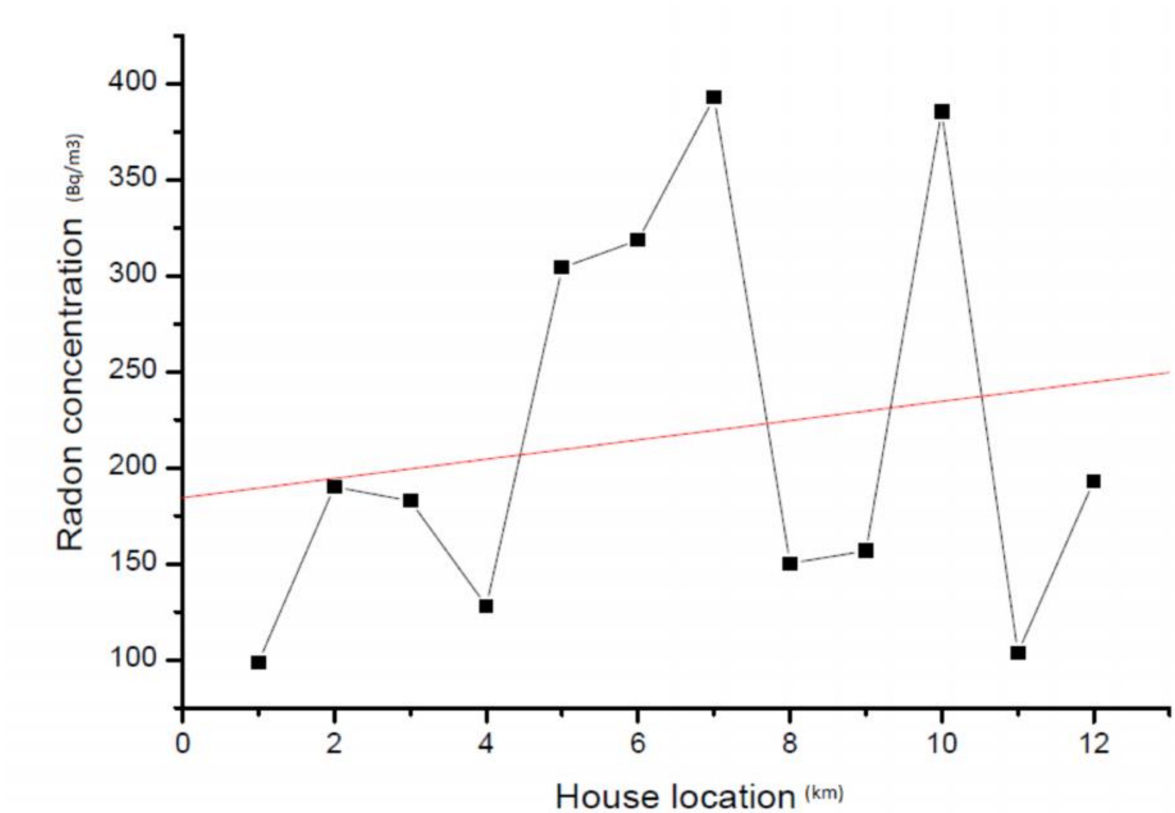

Fig 2: variation of radon concentration versus distance

The fig.2 shows radon concentration (Bq.m−3) verses house location (km). No certain trend is found in the variation of radon concentration verses distance. It is a random variation. The solid line represents the average of variation of radon concentration verses distance. Dwellings coded as 6, 7 and 10 have higher radon concentration than other dwellings. This higher value may be attributed to stone used as the building material and unventilated. In the dwelling 5 the same stone has been used as building material but this house is ventilated so it has relatively lower radon concentration. In the dwelling coded as 12, the same stone is used as the building material and it is unventilated also, but the radon concentration is less than the dwellings coded as 5, 6, 7 and 10 because it is on the first floor (higher altitude) [1]. The dwelling 1- 4 have lower concentration of radon as these are built up of soil only (no stone, cement etc) and ventilated also except dwelling 3. Dwelling 3 is unventilated but has the lower concentration of radon than dwelling 2, which is ventilated; this lower value may be attributed to the roof made of transparent materials. In the dwelling 8 stone was used as building material and it was unventilated while dwelling 9 is made of soil only and ventilated also but little higher radon concentration than dwelling 8 because it was painted. Dwelling 11 has lower value of radon concentration as it is built up of concrete and has direct cross ventilation.

CONCLUSION AND RECOMMENDATION

The results of this study show that the concentrations of radon and inhalation dose vary from dwelling to dwelling. The results have been found lower or within the safe limit (200 to 600 Bq.m^{-3}) as recommended by ICRP but 75 percent of them are higher than the action level of 4pCi/L (148 Bq.m^{-3}) as recommended by EPA. Around 33% dwellings have radon concentration higher than the action level of 200 Bq/m^{3} as recommended by World Health Organization (WHO) so remedial action is advised in these dwellings. Stone and unventilation is found as the main sources of higher radon concentrations. Ventilated dwellings have lower radon concentrations than unventilated ones. Radon concentration decreases with height.

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