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Indoor Radon Concentration Measurement in Different Iraqi Radiation Locations

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Abstract- In this work, the outdoor radon concentration level and lung cancer risks have been measured in different Iraqi radiation locations during the summer season 2012 by using time integrated passive radon dosimeters containing LR-115 Type II plastic track detectors. These measurements were carried out in the locations for an exposure time of 60 day. The radon concentration in these locations ranges from (70.80 – 103.49) Bq.m^{-3} with an average of (89Bq.m^{-3}), which within the acceptable radon levels (50-150) Bq.m^{-3} recommended by the International Commission on Radiological Protection (ICRP). The average absorption effective dose equivalent for a person living in locations for which the investigation were done was found to be (2.117mSv.y^{-1}). It is observed that the average lung cancer per year per 10^{6} person was found to be 38.1.

Keyword - LR-115 Type 11 Nuclear Track Detectors, Radon Concentration, AEDE, PAEC.

I. INTRODUCTION

The radon isotopes are produced from the decay of the natural radio nuclides (^{235}U), (^{232}Th) and (^{238}Rn) mainly because of their short half-life are not as important as (^{222}Rn). (^{222}Rn) can be considered to be of the most dangerous radioactive elements in the environment. Its character as a noble gas allows it to spread through the atmosphere [1].

The main natural sources of indoor are soil, building materials (sand, rocks, cement, etc), water born transport, natural energy sources like (gas, coal, etc) which contains traces of(^{238}U) [1, 2]. The indoor radon consecration depends mainly on radon exhalation from surrounding materials. (^{222}Rn) and is airborne daughters can cause a significant internal health hazard (for example lung cancer) especially when uranium or radium content in the soil is high or when the radon and its daughters are concentrated in enclosed area and in particular in dwelling. Several reports have appeared in literature demonstrating that residential radon may be responsible for 7% of lung cancer in Germany, 4% in Netherlands, 20% in Sweden and (10-15%) in the united states [3].

Concentration of (^{222}Rn) gas in dwelling gas been reviewed and summarized by the UNSCEAR, data available for over 20 European countries and these show that average radon concentration varies widely, from (< 25 Bq.m^{-3}in) the Netherlands, the united kingdom and Cyprus, to over 100 Bq.m^{-3} in Estonia, Finland, Sweden, Luxembourg, the Czech republic, Hungary and Albania for many countries, the variation in indoor radon levels within the country is enormous, and individual dwellings with radon gas concentrations above (10000 Bq.m^{-3}) have been found in Finland, Norway, Sweden, Belgium, Germany, Switzerland, the united kingdom, the Czech republic and Spain [4, 5].

Measurement of indoor radon is rather important because the radiation dose to human constitutes more than

60% of the total dose, including that from the natural sources [6]. Several techniques have been used to measure radon and is daughters concentration. Solid state unclear track detectors, such as LR-115 and CR-39, have been widely used for the measurement of time integrated radon levels in dwellings under different conditions [7-12].

The present study aims to measure some important parameters such as the outdoor radon (^{222}Rn) concentration in selected factories, the potential alpha energy concentration, the absorption effective dose exposure and the lung cancer cases per year per 10^6 person. These evaluations can help in stabling a reference level of activity concentrations from which any further increase in those levels for any reason could be detected.

II. EXPERIMENTAL PROCEDURE

This study assesses the indoor radon concentration in different radiation locations in Iraq. LR-115 Type II nuclear track detector sheets of active layer 12 µm thick were used. These sheets were cut into small pieces of 1.5×1.5cm^2 area each. The sheets were stored under normal laboratory conditions, and then suspended in ceilings for two months in places under study (exposed in Bare mode). The track density so obtained was converted into the units of Bq m^{-3} of radon concentration using the calibration factor determined by SubbaRamu *et al.* (1988) and assuming an equilibrium factor of 0.4 between radon progeny and radon [13], the detectors were collected and chemically etched using solution of 2.5 N of NaOH at temperature of (60 ^{o}C) for 2 hours. After etching, the detectors were rinsed in distilled water and cleaned. An optical microscope with a magnification of 400X was used to count the number of tracks per cm^2 in each detector.

Figure 1 shows the calibrations curve for radon standard samples and track density. Radon concentration in the samples was measured by comparing between track density registered on the detectors and that of the standard derived from equation 1[14]. LR-115 detectors were positioned in direct contact with the outdoor air at several specific locations in Iraq for 60 days as shown in figure 2. During exposure, alpha particles emitted by radon, thoron and their progenies bombarded the detectors.

$$C_x = \rho_x . (C_s/\rho_s) \quad (1)$$

Where ρ_x and ρ_s are the induced fission track densities for unknown sample and standard solution (in tracks/mm^2) respectively, while C_x and C_s denote the uranium concentration for unknown sample and standard solution (in µg/l) [15].

The following parameters were deduced from technique:

i) The Potential Alpha Energy Concentration (PAEC) in Working Level (WL) of radon daughters is estimated using the following equation [1, 16].

$$C_d = F\, C_{Rn}/3700 \quad (2)$$

Where F is the equilibrium factor and equal to 0.4 and C_{Rn} is the activity concentration of radon in Bq.m^{-3}.

ii) The Absorption Effective Dose Equivalent (AEDE) is estimated by using the dose conversion factor 5.5 mSv/WLM [1,17].

$$\text{AEDE (mSv.y}^{-1}) = (5.5\text{mSv/WLM}) \times (\text{WLM/y}) \quad (3)$$

iii) The lung cancer per year/10^6 person is estimated by using the risk factor lung cancer induction 18×10^{-6} mSv^{-1} [1, 17].

Lung cancer per year par 10^6 person is equal to $\text{AEDE(mSv.y}^{-1}) \times 18\times10^{-6}\ (\text{mSv}^{-1})$ (4)

III. RESULTS AND DISCUSSIONS

The results of the radon concentration in air samples of locations were given in Table I and it was observed that they varied from 70.80Bq/m^3 in X-ray unit to 103.49Bq/m^3 in MST (Ministry of Science and Technology), the result shows that the average radon concentration in samples from MST (highest) is a factor of 1.46 higher than that from the X-ray unit (lowest), similarly the average radon concentration in samples from the CTS (Computed Tomography Scanner) is a factor of 1.307 higher than the average radon concentration in samples from the X-ray unit, and the average radon concentrations in samples from the CTS and MST locations are similar to each other (as shown in figure 3)..

This illustrates that the CTS and MST had radon levels higher than other locations in this study [X-ray unit and NMD (Nuclear Medicine Department)], but it is acceptable because it lies within the radon levels recommended by the international commission on radiological protection (ICRP), and the average radon concentration for all locations also within the acceptable radon levels (50 - 150) Bq/m^3 recommended by the international commission on radiological protection (ICRP) [18].

Table II is summarized the value of radon concentration C_{Rn} (Bq/m^3), the potential alpha energy concentration PAEC (WL), the absorption effective dose exposure AEDE (mSv.y^{-1}) and the lung cancer per year per 10^6 people. The values of radon concentration for all locations ranged from (70.80 to 103.49) Bq/m^3 with the average value of 89 Bq/m^3, the highest value of potential alpha concentration (PAEC) levels in the CTS unit 10.8 mWL with average value of 9.625 mWL, likewise MST and CTS had an average values of potential alpha concentration (PAEC) levels of more than 10 mWL. While the lowest value 8.2 mWL. The absorption effective dose exposure equivalent ranged from (1.810 to 2.366) mSv.y^{-1} with an average value of 2.117 mSv.y^{-1}. The report (ICRP) recommended that action levels of radon should be within a range of (3-10 mSvy^{-1}) [19, 12]. According to this study, the radon induced lung cancer risk ranged from (32.575 to 42.584) per million persons, with an average of about 38.1 per million persons, the CTS unit and MST had similar value of the radon induced lung cancer risk per year at more than 40 per million persons.

IV. COMPARISON WITH SOME OTHER RESULTS

Table III shows a comparison of average values of the radon concentration in Bq/m^3 for some countries. The results in this study were in agreement with data available in another study for Jordan and less than other findings in India, Spain and north Iraq but greater than findings in Hong Kong, Italy, Japan Canada and south Iraq.

V. CONCLUSION

The higher radon concentrations in air samples were 103.49Bq/m^3 from MST, and the minimum concentrations 70.80Bq/$m^3$from X-ray unit, the average radon concentration in samples from CTS (highest) and MST locations are a factor of (1.307 and 1.282) higher than from X-ray unit (lowest). These average radon concentrations in samples from CTS andMST locations are close to each other.

The radon induced lung cancer risk was measured ranges from (32.575 to 42.584) per million persons, with an average of about 38.1 per million persons. Therefore the CTS unit and MST locations are the most dangerous than other locations at this study.

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Table I

Average, maximum and minimum radon concentration in samples (Bq/m^3)

Locations	**No. of Samples**	**Average radon concentration**	**Maximum radon concentration**	**Minimum radon concentration**
CTS unit	4	99.47	101.47	98.00
MST	5	97.53	103.49	91.53
NMD	10	82.91	91.82	75.71
X-ray unit	10	76.09	80.44	70.80

Table II

Measurement of radon concentration, the potential alpha energy concentration, the absorption effective dose exposure and the lung cancer cases per year per 10^6 person

Location	**C_{Rn}(Bq/m^3)**	**PAEC (mWL)**	**AEDE (mSv.y^{-1})**	**Lung Cancer/10^6 person**
CTS unit	99.47	10.8	2.37	42.58
MST	97.53	10.5	2.32	41.75
NMD	82.91	9.0	1.97	35.49
X-ray unit	76.09	8.2	1.81	32.58

Table III

A comparison of radon concentration in air (Bq/m^3) for some countries

Country		C_{Rn} (Bq/m^3)	PAEC (mWL)	AEDE (mSv/y)	Ref.
Iraq		103.98	17.2	2.47	Battawy and Hussein
		13.53-51.18	--	--	Al-Gaim*et al.*
Jordan		33.28	--	--	AL-Kofahi*et al.*
		29.3 to 99.7	--	--	Abumurad*et al.*
Hong Kong		48±32	5.2±5.1	--	Yu *et al.*
Brazil		5 - 20	--	--	Magalhaes*et al.*
Italy		5 - 15	--	0.12	Magalhaes*et al.*
Japan		6.1	--	0.45	Oikawa *et al.*
India	TajMahal	213	--	1.3 - 4.4	Kumar *et al.*
	Punjab	84.93 - 128.53	--	1.45 - 2.19	Badhan*et al.*
	Garhwal and Kumaun	11 - 191	--	--	Ramola
	western Haryana	76 - 115.46	--	--	Kansal*et al.*
Spain		above 400	--	--	Sánchez, *et al.*
Canada		41.9	--	--	Chen *et al.*
Iraq		89	9.625	2.117	Present study

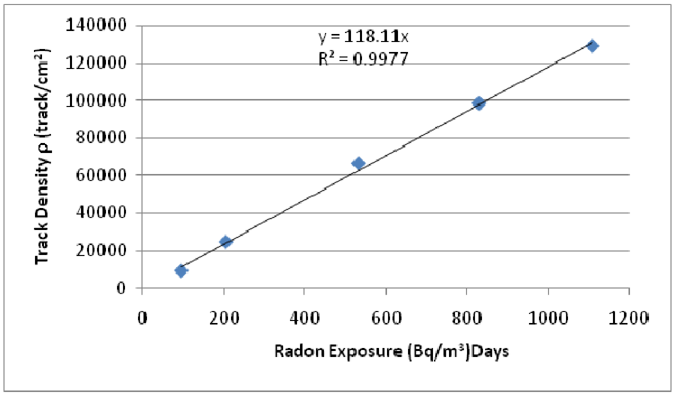

Fig.1. Relation of radon concentration and track density in standard samples

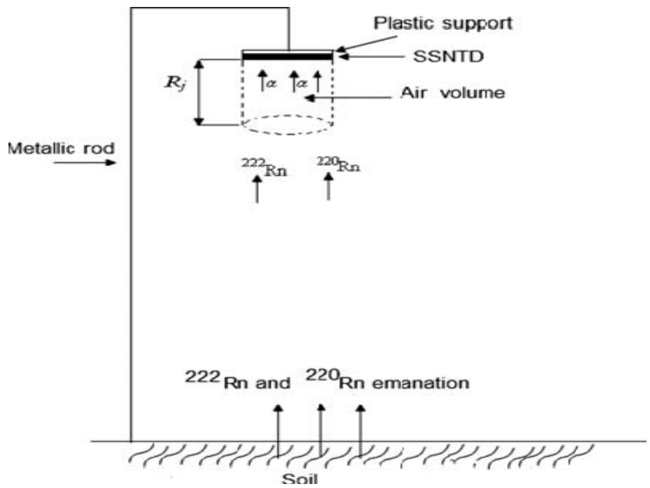

Fig. 2. Arrangement of the LR-115 detector of (1.5×1.5) cm^2 placed in the outdoor air. The distance between the detectors and the ground level is 2.5m

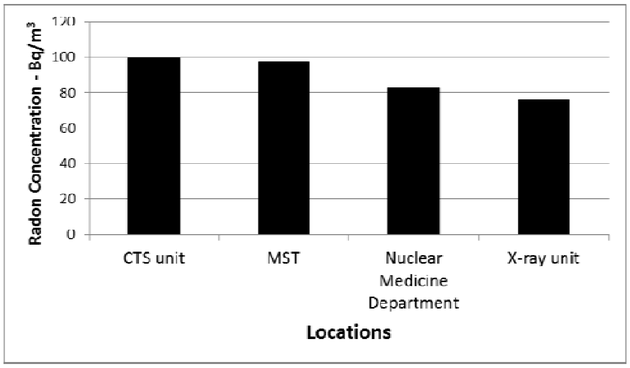

Fig. 3. Histogram of radon concentration in locations