Asses of Indoor Radon Dose and its Risks on children's Health using Track Detectors: Case Study in Koya Kindergartens

تقييم جرع غاز الرادون و مخاطرها على صحة الاطفال باستخدام كواشف الاثر: دراسة الحالة في روضة مدينة كويسنجق

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Abstract

In order to assess effects of long term exposure of radon gas, CR-39NTDs exposed to indoor radon during summer season in the rest halls (ground floor) of 20 selected Kindergartens of the districts of Koya, Iraqi Kurdistan. Ventilation rate affect on the results of indoor radon concentration for each kindergarten. Good ventilation got a low level of indoor radon as measured inside Papula Kindergarten: opposite of that of poor ventilation rate got a high level of indoor radon, as measured inside Hang kindergarten.

Average of high value of indoor radon concentration ($Bq/.m^3$), annual effective dose (mSv/y) ,and potential alpha energy concentration (WL) were equal to (45.459±8.546) $Bq/.m^3$,(0.281) mSv/y, and (0.056) mWL, respectively.

Results were compared with some international reports and references that used CR-39NTDs to asses of indoor radon concentration. It was under the levels that mentioned in other references.

Keywords: Indoor radon, CR-39NTDs, Kindergartens, radiation dose, and ventilation rate

الملخص

لغرض تفييم تأثيرات التعرض لغاز الرادون لفترات طويلة ، تم تعرض كواشف الاثر النووي الصلب من نوع (CR-39) الى غاز الرادون الداخلي داخل قاعات 20 روضة اطفال في قضاء كويسنجق في كوردستان العراق خلال موسم الصيف. بينت النتائج على ان معدل التهوية اثرت على نتائج تركيز عاز الرادون لكل روضة . وجد عند التهوية الجيدة انحفاض في تسجيل تركيز غاز الرادون كما في روضة ببولة ، على عكس ذالك وجد عند التهوية الرديئة ارتفاع في تسجيل تركيز غاز الرادون كما في روضة هنك.

وجد ان اعلى معدل لتركيز غاز الرادون الداخلي و الجرعة السنوية الفعالة و تركيز طاقة جهد الفا كان (8.546±45.459) Bq/m^3 و (0.281) mSv/y و(0.056) mWL على التوالي.

تم مقارنة النتائج مع نتائج بعض التقارير و المصادر الدولية التي استحدمت كواشف الاثر النووية الصلب لتقيم تركيز غاز الرادون ، ووجدت انها كانت تحت المستويات المنشورة في تلك المصادر.

1. Introduction

Radon (^{222}Rn) is a naturally radioactive gas with a half- life of 3.824 days. It is the immediate progeny of radium (^{226}Ra). Atoms of radon in the air decay within a few days into its short- half life radon daughters, which decay within about an hour; with these decays, three alpha particles are emitted, one by radon an two by its daughters. When radon and its short-lived decay products are inhaled, the radiation dose to lung tissue is dominated by the alpha particles emitted by the deposited decay products. These products, especially those attached to small size aerosols or that remain in unattached form, cause damage to sensitive lung cells [1].

Alpha particles are high linear energy transfer (LET) radiation and carry sufficient energy to cause permanent dames to DNA [2]. In addition, a number of in vitro studies using radon gas were defined for understanding the early changes induced at cellular and molecular level and DNA repair of these events. The studies proved that radon is capable of inducing significant chromosome damage event at very low doses and low dose-rate [3]. The studies proved that radon is capable of inducing significant chromosome even at very low doses and low dose- rate [3]. As well as, high ratio of indoor radon has impact of the male fertility [4], this more effects on the infertility of the male children.

In solid state track detectors as CR39 and other polycarbonate compounds, the path of an ionizing particle along the damaged trail is revealed by a conical pitch which is visible to microscopic analysis after a chemical etching. The pitch characteristics depend on properties of the etching solution and on travelling ion, so to allow determination of ion properties. So nuclear track detectors (NTDs) register alpha particles emitted by radon gas and its progeny in the form of tracks, which will become visible under the optical microscope upon suitable chemical etching of the NTDs [5]. Interesting of radon dosimeters depended on the calibration factor, this factor has a wide range depends not only on the geometry of the used configuration but also on many parameters such as; type of the sued detector via their etching conditions, detector efficiency and the dosimeter dimensions [6-7]. A recent review on NTDs has been given in references [8-9]. In the present study, indoor radon levels and effective dose (H_E) measured inside halls of kindergartens in Koya city in Iraqi Kurdistan that have several of kindergartens using CR-39NTDs.

2. Research methodology

2.1 Area under study

Koya city is located in the north of Erbil Governorate (capital of Iraqi Kurdistan), and that region is a mountain region with a complex geological formation (Fig.1). Latitude and longitude of Koya 36.1244 and 45.1778, respectively. It is located in the Erbil Governorate of Iraqi Kurdistan and close to the Iranian border.

2.2 Materials

2.2.1 CR-39 NTDs

The CR-39 plastic track detector is a $C_{12}H_{18}O_7$ polymer with density 1.3 g/cm and its thickness is 700µm. CR-39 detectors used in the present study were produced from INTERCAST EURIPE SRL (43100 Parma-Italy), and cut into (1×1.5) cm engraved code. It was calibrated by Ismail in previous work [10] , and its efficiency in 6N NaOH at $70^{o}C$ of chemical etching was $80.3 \pm 1.67\%$.

2.2.2 Radon Dosimeters

Radon dosimeters (see Fig.2) have a cylindrical shapes with the dimensions (height =7cm: diameter = 6cm) were equipped with CR-39 and covered with sponge membrane (0.5 cm thickness) for discrimination between radon and its isotope (^{220}Rn), the dosimeters are calibrated in previous work to calculated the calibration factor(K)[10].

2.3 Experimental procedures

Radon dosimeters (see Fig.2) equipped with CR-39 (INTERCAST EUROPE SRL) were distributed inside rest halls (four for each hall) of the 124 halls of the kindergartens were known. Place of installed exposure chambers was 50cm under the roof of the hall on the single-walled. After 90 days of exposure, the dosimeters were collected and chemically etched in 6N

NaOH at 70oC for 9h . An optical microscope with a magnification of 200 was use to account the number of tracks per cm2 that occurred in each detectors, as shown in Fig.3.

2.4 The measurements

2.4.1 Indoor radon concentration

Average radon concentration in the halls of Kindergartens measured by passive methods for the summer season and calculated as [11];

$C_{Rn}(Bq/m^3)= \rho/kt$ (1)

where ρ is the track density (track/cm^2), k is the calibration factors =2.68 cm [10], and t is the exposure time (=90 days).

2.4.2 Potential alpha energy concentration (WL)

The measured ^{222}Rn values can be converted into (WL) if the equilibrium factor F is known from the following formula [12];

$WL= F\ C_{Rn}/3700$ (2)

2.4.3Personal dosimeter

The effective dose (H_E) of radon and its progeny obtained by relation [13];

$H_E= C_{Rn}\ \{\mathbf{do}+\mathbf{de}\ \mathbf{a}\exp(\mathbf{b}Do/D)\}$ (3)

Where **do** and **de** are the recommended values for the effective dose conversion factors for radon and its progeny as do= 0.33 $\mu Sv.y^{-1}$ per $Bq.m^{-3}$ and , de= 80 $\mu Sv.y^{-1}$. D and D_0 are the track densities (track/cm^2.day) for open and filtered dosimeter respectively.

3. Results and Discussion

Results of indoor radon concentration and its risks on children health in selected location in Iraqi Kurdistan are listed in Table 1.

It is clear that the annual effective dose depended on the level of radon concentration and its daughters inside the halls of kindergartens. As well as, the values of radon concentration and the risk factors were variable from Kindergartens to other, depending on the rate of air moving (hr/day), and this clarified in Fig.4 and Fig.5. The distribution of average concentration of indoor radon inside kindergartens of Koya city in Iraqi Kurdistan was approximately lognormal (normal logarithmic) within summer season. High and low levels of indoor radon depended on the ventilation rate. Good ventilation rate got a low level of indoor radon as registered inside Papula kindergarten; opposite of that poor ventilation rate got a high of indoor radon as registered in Hang Kindergarten

In general, the average of high value of indoor radon concentration (Bq/m^3), annual effective dose (mSv), and potential alpha energy concentration (WL) were equal to 45.459±8.546 Bq/m^3, 0.281 $mSv.y^{-1}$,and 0.056 mWL, respectively. Results are compared with some international reports and references that used CR-39NTDs to detect indoor radon gas for some kindergartens and schools for different countries (Table 2). It is clear that the present results were under the levels that mentioned in other reference, depending on the environmental parameters, dwellings type/construction and the grade of uranium in their lands.

4. Conclusion

Indoor radon concentration, potential alpha energy concentration, and annual effective dose estimated inside Kindergartens of Koya city in Iraqi Kurdistan, using CR-39 plastic detectors. Aannual effective dose depended on the level of radon concentration and its daughters inside the halls of Kindergartens. The values of indoor radon concentration and the risk factors were variable from kindergarten to other, depended on the rate of air moving (hr/day). High levels of indoor radon depended on the ventilation rate. Good ventilation rate got a low level of indoor radon as registered

Papula kindergarten; opposite of that, poor ventilation rate got a high indoor radon as registered in Hang kinder garden. Results were compared with some international reports that used CR-39NTDs to measure a concentration of indoor radon gas, and found that the present that the results were under the levels that mentioned in other references.

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Fig.1: Google map of the Koya city (Red squares are the area of under study)

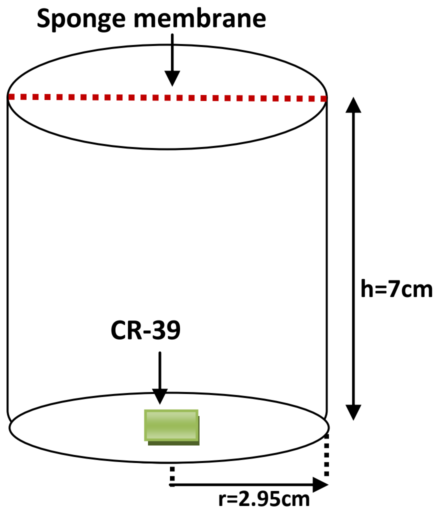

Fig.2: Schematic diagram of the exposure and calibrated dosimeter [10].

Fig.3: Alpha track registered by CR-39NTDs

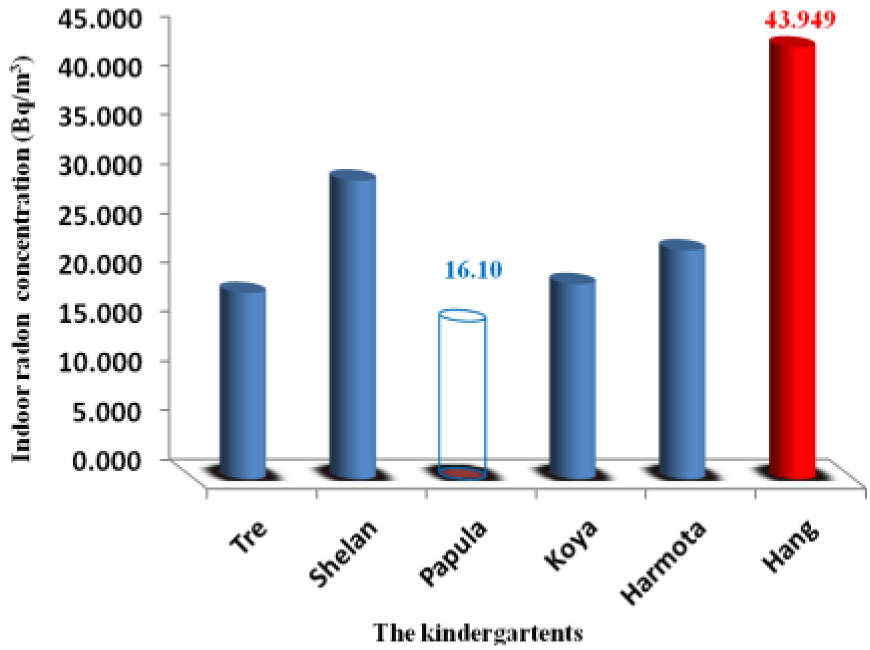

Fig.4: Levels of indoor radon concentration with the Kindergartens type

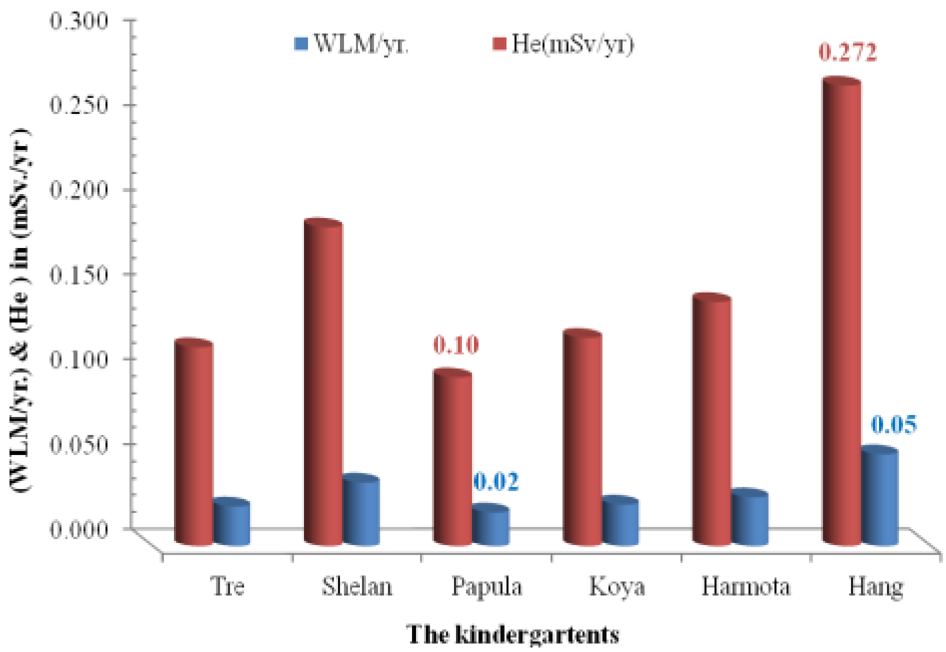

Fig.5: Variation of alpha energy concentration and annual effective dose per each kindergarten.

Table 1: Results of average radon concentration, potential alpha concentration, and annual effective dose for each kindergarten

	Kindergartens	Ventilation rate	Average radon concentration(Bq/m^3)	PAEC(mWL)	WLM/yr.	He(mSv/yr)
1	Hang	poor	43.949±10.580	4.751	0.054	0.272
2	Harmota	partial	23.329±4.453	2.522	0.029	0.144
3	Koya	good	19.894±8.011	2.151	0.025	0.123
4	Papula	good	16.103±5.737	1.741	0.020	0.100
5	Shelan	partial	30.430±6.938	3.290	0.038	0.188
6	Tre	good	18.977±7.663	2.052	0.023	0.117
7	Zanko	poor	45.459±8.546	4.915	0.056	0.281

Note: House is considered to have a poor ventilation rate (movement rate of the air is poor) if it has 1 door + 1 window +1fan, with an operation time less than 8hour/ day. Partial ventilation rate has been considered if an air cooler has been added with an operation time between 8-12 hour/day. Good ventilation rate is considered if there is an air conditioner plus an exhaust fan added, with an operation time more than 12 hour/day

Table 2: Comparison results of average indoor radon gas that t used CR-39NTDs for different countries.

Country / Regions	Average radon concentration (Bq/m^3)	References
Iraqi Kurdistan (schools)	96.815 ±26.93	14
Koya city	28.306±12.07	Present study
Swabi, Pakistan	27- 70	15
Province of Trabzon/ Turkey	38-114	16
Italy (5-12) regions (kindergartens)	38-118	17
Norway (kindergartens)	Geometric mean 44	18
Slovenia (kindergartens)	Geometric mean 58	19
Belgium / Luxembourg (School)	200-400	20
Islamic Republic of Iran (School)	55-400	21
Ireland(school)	200-2680	22
Italy (3 of 21 regions) (school)	Geometric mean 78-129	23
USA (school)	150-2500	24