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Estimation the dose on radiosensitive tissue for women in dwelling and health risks caused to reduce the fertility women and cancer in gonads in Iraqi Kurdistan regions.

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Abstract

Present work, described the risk of indoor radon concentration on the women ʾs body tissue, such as bladder, gonads, and uterus. Minimum and maximum annual effective dose A. E. D. to uterus and many tissues were found 2.39 m Svy^{-1} and 32.28 $mSvy^{-1}$, respectively. The lowest radon concentration detected was found in the living room 94.883 Bq m^{-3}, and the highest radon concentration detected was found in the kitchen 364.412 Bq m^{-3}. The distribution of indoor radon concentration was high in many houses and many pose health risk affected on women fertility causative the infertility and cancer in gonads. The large variation of the indoor radon activity between different dwellings can be explained depending on the age of the house, ventilation conditions and the type of building materials, nature of the soil underneath, and geological considerations. Majority of the houses had poor ventilation attributed to the absence of ventilators. Dose is higher in old houses than in new ones because the ventilation rates in new houses are higher than those in old houses. The results showed significant difference (p value < 0.001) found between kitchen and living results, where concentration of radon in kitchen had higher results medians than results of living. Significant difference (p value < 0.001) found among organs in living room, where the gonads are the organ with highest concentration while bladders were the lowest, also significant difference (p value < 0.001) found among participants organs in kitchen room

Key words: Infertility, gonads cancer, indoor radon, human risk, CR-39NTDs, annual effective dose.

1. Introduction

The biological effects of radon are predominantly attributed to the alpha particle activity of ^{222}Rn and two of its solid decay products ^{214}Po and ^{218}Po as well as the deposition of ^{218}Po and ^{214}Po in the lungs because of radon inhalation. Radon inhalation results in damage to the living cell. Exposure to radon varies depending on the concentrations present in homes (Hamza, 2009). When radon enters the indoor atmosphere inside the house, it accumulates in poorly ventilated rooms to levels that may pose a significant health risk to the occupants (Rahmana, 2011). Measurements were performed in the kitchen and living room, or in the rooms where the women spend most of their time.

The CR-39 plastic track detector is the most reliable instrument to measure radon over time to estimate the equivalent concentration of radon and progeny. The study also employed the longitudinal method to measure radon activities under different environmental conditions. This study suggests that detected indoor radon alpha activity in the Kurdistan region of Iraq has adverse health effects on the population. The study also extracts information on how radon and alpha particles damage the uterus and cause weakness fertility among women. This study is the first to explore the effects of radon exposure in the kitchen and living room.

The CR-39 is an alpha sensitive solid state nuclear track detector and is used in this study to measure indoor levels of radon. The method is economical and reliable (Mansour, 2005). Knowledge of radon levels in building is important in assessing population exposure (Kadam, 2011). The main natural sources of indoor radon are soil, building materials (e.g., sand, rocks, cement, and others), tap water, and natural energy sources used for cooking (e.g., gas, coal, etc.). Many factors influence the amount of radon emitted into a home, such as the rocks on which the home is built and how much soil or other materials cover the radon-emitting rocks (Rahmana, 2011). The purpose of this study is to analyze the effect of radon on pregnant women and fertility of women in most locations in the Iraqi Kurdistan region using a passive method technique of CR-39 NTDs. The risk deposition of the alpha particles emitted from radon on the uterus of women and other tissues in the body, causing changes in the cells, is evaluated depending on the track density of the alpha particles, radon concentration, and annual effective dose.

2. Building characteristics

The dwelling units under study were built using different materials, such as cement, sand stones and bricks, iron structure, marble, and concrete. Several of these materials contribute significantly to indoor radon emission. Each house had at least two to three rooms and one kitchen, measuring 5 m x 4 m x 4 m, with one window and one door. A room without any windows is considered poorly ventilated, whereas a room with one or more windows is considered well ventilated (Kadam, 2011).

3. Methodology

In the present work, air radon measurements were carried out using CR-39 (pollyally diglycol carbonate) NTDs. The rectangular piece of the NTD is 15, 10, 0.7 mm in size and 1.30 g cm^{-3} in density. The passive radon dosimeter geometry is a closed chamber into which radon diffuses. The chamber is a tube made of PVC, and it has a diameter of 2.1 cm and length of 10.5 cm. The design of this type of radon detector ensures that only radon diffuses into the sensitive volume of the chamber, and all the aerosols and radon decay products are kept outside (Leghrouz, 2011, Rafique, 2010). The design of tube is presents in Fig. 1.

The tubes were placed at a height of about1.5 cm (Narula, 2009) from the ground in the kitchen and living rooms for each house. A bout 50% of the dosimeters in houses was placed in living rooms, 50 % in kitchens. Left all chambers without removed them for time duration of 60 days. The detectors were collected after an exposure time of 60 days and the detectors were etched separately with a NaOH solution in 6.25 N solution of NaOH at a temperature of $70.0 \pm 0.5\ ^{o}C$ for 8 hours to enhance the damaged tracks (Rafique, 2010). For measuring radon concentration that is connected with the track density, an optical microscope is used to this measure.

4. Measurement of radon concentration and annual effective dose

The main objective of this work was to assess the indoor radon concentration, the annual effective dose rate, the annual dose equivalent rate to the uterus and many body tissues for the body and the associated level of risk to the populace under study area. The radon concentration is calculated from the track density by the formula in Ref (Alberigi, 2004) as shown in Table 3 and Fig. 2.

In order to estimate the annual effective dose received by the women, the annual absorbed dose, is usually expressed in the unit of m Sv y^{-1} using the formula (Nsiah-Akoto, 2011, Issa 2007**,** Rafique et al. 2010)

$$D_{Rn}\,(mSvy^{-1}) = C \times F \times H \times T \times D \qquad (1)$$

Where,

C : is the concentration of radon ($Bq.m^{-3}$)
F : is the radon equilibrium factor indoor (0.4)
T : is the indoor occupancy time ($24h \times 365 = 8760hy^{-1}$)
H : is the indoor occupancy (0.4)
D : the dose conversion factor (9.0×10^{-6} $mSvy^{-1}/ Bq.m^{-3}.h^{-1}$)

In the biological effect of radiation, to calculate the annual equivalent dose and effective dose, two types of weighting factors are needed in order to estimate the level dose. A radiation weighting factor and a tissue weighting factor. The radiation weighting factor (W_R) for alpha particles is 20 as recommended by ICRP, 1991, as shown in Table 1 (ICRP, 2011) and a tissue weighting factor (W_T) is applied. The weighting factor for many tissues are listed in Table 2 (Mossadegh, 2011, Issa, 2007).

Radon progeny concentration WL is calculated using the formula in reference (Mansour, 2005). The same calculations are used to determine and calculate cancer cases per year per million per person (m Sv y^{-1}) and the life time risk (Mansour, 2005). The measurements depend on the tissue weight factor, and they are based on guidelines given by the International Commission on Radiological Protection (ICRP) and the United Nations Scientific Committee, on the Effects of Atomic Radiation. The annual effective dose was then calculated using the following equation (Alberigi, 2004)

$$H_{E\,(mSv\,y-1)} = D_{Rn}\,.\,W_R.\,W_T \qquad (2)$$

Where

$H_{E\,(mSv\,y-1)}$ is the annual effective dose
D_{Rn} is the annual absorption dose
W_R is radiation weighting factor
W_T is tissue weighting factor

The excess lifetime cancer risk (ELCR) for the living room and kitchen was calculated using formula in Ref (Obed, 2011) as shows in the Table 7.

$$\boldsymbol{ELCR = H \times DL \times RF} \qquad \textbf{(3)}$$

where

DL is the Duration of Life (70 y).

RF is the Risk Factor (0.055 Sv^{-1}) recommended by the ICRP

5. Statistical analysis

Statistical Package for the Social Sciences (SPSS) version 20 used in analysis the results of current study, All statistical calculations were performed using SPSS for Windows, Standard version 20.0. The data of the research were saved in Microsoft Excel Spread sheet and analyzed on the computer using Microsoft Excel program used in this analysis. Friedman test and Wilcoxon Signed Rank test were used for comparison among multiple groups and between two groups respectively

6. Results and discussion

This study is the first study to investigate radon levels in two rooms in dwelling units in different locations in the Iraqi Kurdistan region and the novelty is that the radon concentration in dwelling affect on the uterus. Radon exposure and inhalation of radon progeny gases present in the rooms of dwelling units affect many body tissues, such as bladder, gonads, and uterus. When the radon enters the lungs, the blood carries this radon from the lungs into the body tissues to the uterus. The women in Kurdistan spend most of their time at home; therefore they are exposed to radon gas. Generally, indoor radon activity concentrations are measured in the kitchen and living rooms in 60 location in the Iraqi Kurdistan region. Radon levels differ from one room to the other in the same house. The results indicate that radon levels are higher in the kitchen than in the living room. The highest average radon concentration level was found in the kitchen in Halabjay-kon (364.412 Bq m^{-3}) and the lowest average radon concentration level was found in the living room (94.883 Bq m^{-3}). This large variation of the indoor radon activity between different dwelling units in these localities and the indoor radon data obtained from all dwellings in the study area can be explained and analyzed depending on the age of the house, ventilation conditions and the type of building materials, nature of the soil underneath, and geological consideration. Another main difference noted is in the size of the rooms. Living rooms were larger than kitchens, and they had more windows.

Table 3 shows the minimum , maximum values and average indoor radon concentration in kitchen and living room, also shows the radon levels in the kitchen are seen to vary from 98.917 to 362.262 Bq m^{-3} with an average activity value of 187.215 Bq m^{-3}, and the indoor radon levels in the living rooms varied from 94.883 to 358.032 Bq m^{-3} ,

The annual mean effective dose is 4.795 mSv y^{-1}in the living room and 5.1633 mSv y^{-1} in the kitchen. The minimum and maximum annual doses in the dwelling units were different, as listed in Table 4. The calculated values of the annual doses for radon vary from 2.391 to 9.017 mSv y^{-1} in the living room and 2.518 to 9.075 mSv y^{-1} in the kitchen, these values are within the recommended action level of 3 mSv y^{-1} to 10 mSv y^{-1}. Majority of the houses had poor ventilation attributed to the absence of ventilators. The dose is higher in old houses than in new ones because the ventilation rates in new houses are higher than those in old houses. The presence of cracks on the floors and walls in old houses enables more radon to enter indoors.

All parameters were affected on the women fertility due to poor ventilation in dwellings of the location under study, causative the infertility of women and cancer in gonads, therefore the infertility of women was diffusive among the women, as presented in Table 5.

Table 5 shows the many parameters of the results in the kitchen and living room and how they affect the fertility of women. Significant difference (p value $<$ 0.001) found between kitchen and living results, where kitchen laboratory results had higher medians than results of living

Friedman test was used for non-parametric results to find the difference among participants' organs in both living and kitchen rooms. Significant difference (p value $<$ 0.001) found among organs in living room, where the gonads are the organ with highest concentration while bladders were the lowest, also significant difference (p value $<$ 0.001) found among participants organs in kitchen room, where gonads were the organ with highest concentration. while bladder were the lowest, as shown in Tables 6, 7. The affects of radon on the biological tissue body were explained in Figure3.

Tables 8, 9 shows the relation between the effective dose (mSv y^{-1}) on the fertility of women in the living room and kitchen with excess life time cancer risk in dwelling units in the Iraqi Kurdistan region, and the distribution of the annual dose in the kitchen and living room affects on the uterus for women in different locations in the Iraqi Kurdistan region,

. In this study, the global average annual effective dose of ionizing radiation from natural sources is estimated to be 2.4 mSv y^{-1}, which is about 1.0 mSv y^{-1} is attributed to radon exposure. Based on the EPA recommendation, an immediate intervention is required only if the concentration of radon ^{222}Rn level is above 190 Bq m^{-3}.. The results were compared with other countries, shows in the Table 10. Moreover, if the radon level is above 190 Bq m^{-3}, intervention is required, indicating that the condition is not safe for humans. Most health risks come from the alpha particles deposited in the body. The high availability of uranium in some regions makes it a source of health risk for the public.

7. Conclusion

This study is carried out to measure radon concentration in the living rooms and kitchens and to determine the effect of radon on the fertility of women in Kurdistan. lowest radon concentration detected was found in the living room and the highest radon concentration detected was found in the kitchen. The distribution of indoor radon concentration was high in many houses and many pose health risk affected on women fertility causative the infertility and cancer in gonads. The large variation of the indoor radon activity between different dwellings can be explained depending on the age of the house, ventilation conditions and the type of building materials, nature of the soil underneath, and geological considerations. Majority of the houses had poor ventilation attributed to the absence of ventilators. Dose is higher in old houses than in new ones because the ventilation rates in new houses are higher than those in old houses. The results showed significant difference (*p* value < 0.001) found between kitchen and living results,

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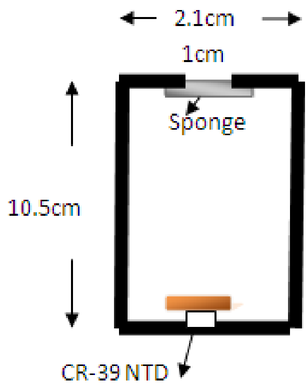

Fig. 1. The fabricated radon detector.

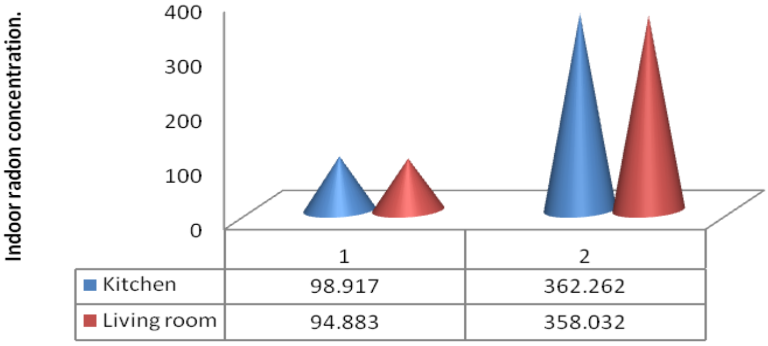

Fig. 2 The nimimum and maximum indoor radon concentration in kitchen room and living room.

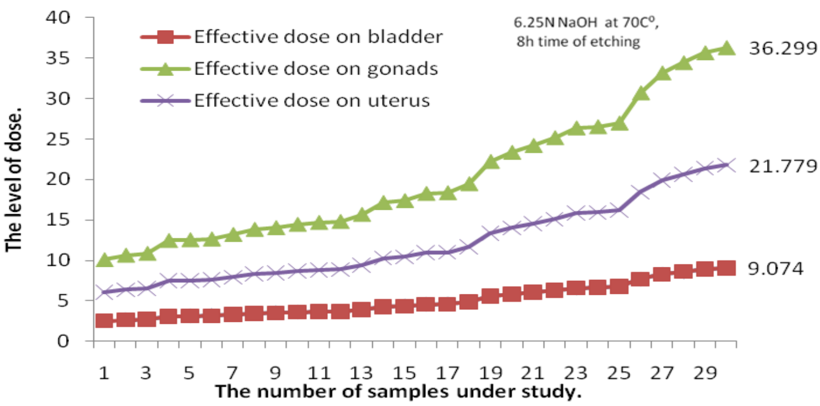

Fig. 3. The relation between the annual absorbed dose in the kitchen room and effective dose on (bladder, gonads, uterus).

Table 1 Recommended radiation weighting factors in 2007

Radiation type	Radiation weighting factor, W_R
Photons	1
Electron and moons	1
Protons and charged points	2
Alpha particles, fission fragments, heavy ions	20

Table 2 Weighting factors for many tissue

Tissue	W_T	
	ICRP 60	ICRP 103
Bone marrow	0.12	0.12
Breast	0.05	0.12
Colon	0.12	0.12
Lung	0.12	0.12
Stomach	0.12	0.12
Bladder	0.05	0.04
Oesophagus	0.05	0.04
Gonads	0.2	0.08
Liver	0.05	0.04
Thyroid	0.05	0.04
Bone surface	0.01	0.01
Brain	Remainder	0.01
Kidneys	Remainder	Remainder
Salivary glands	—	0.01
Skin	0.01	0.01
Remainder tissues	0.05[a]	0.12[b]

Table 2 Tissue weighting factors for calculation of effective dose comparison of 1990 and 2007 ICRP recommendations. Adrenals, extra thoracic region, gall bladder, heart, kidneys, lymphatic nodes, muscle, oral mucosa, pancreas, prostate, small intestine, spleen, thymus and uterus /cervix (Mossadegh, 2011)

Table 3 Min. IRCon., Mix. IRCon., and Ave. IRCon. in different locations under study.

Dwelling	Min. IRC. $Bq.m^{-3}$	Max. IRC. $Bq.m^{-3}$	Ave. IRC. $Bq.m^{-3}$
Kitchen	98.917	362.262	187.215
Living room	94.888	358.032	184.212

IRC, is Indoor radon concentration

Table 4 Average indoor radon concentration in kitchen room and living room in 2 governorates in Kurdistan Iraqi region.

Location	Type of room	Average radon concentration Bq m^{-3}		Average annual effective dose mSv y^{-1}	
		Minimum	Maximum	Minimum	Maximum
Erbil	Kitchen	97.886	364.412	2.713	9.074
	Living room	95.113	358.552	2.457	9.017
Sulaymania	Kitchen	99.947	360.112	2.518	8.607
	Living room	94.883	357.832	2.391	8.254

Table 5 differences of participants' laboratory results between kitchen and living rooms

Variable	Difference		No.	Mean Rank	Z value	*p* value
Conc.	Kitchen – living	Negative Ranks	1	48.00	-6.383	**<0.001**
		Positive Ranks	59	30.20		
		Ties	0			
AAD	Kitchen – living	Negative Ranks	1	48.00	-6.383	**<0.001**
		Positive Ranks	59	30.20		
		Ties	0			
WL	Kitchen – living	Negative Ranks	1	48.00	-6.383	**<0.001**
		Positive Ranks	59	30.20		
		Ties	0			
LTR	Kitchen – living	Negative Ranks	1	48.00	-6.383	**<0.001**
		Positive Ranks	59	30.20		
		Ties	0			
CPPP	Kitchen – living	Negative Ranks	1	47.00	-6.390	**<0.001**
		Positive Ranks	59	30.22		
		Ties	0			
AEqD	Kitchen – living	Negative Ranks	1	48.00	-6.383	**<0.001**
		Positive Ranks	59	30.20		
		Ties	0			
AEFD bladder	Kitchen – living	Negative Ranks	1	48.00	-6.383	**<0.001**
		Positive Ranks	59	30.20		
		Ties	0			
AEFD gonads	Kitchen – living	Negative Ranks	1	48.00	-6.383	**<0.001**
		Positive Ranks	59	30.20		
		Ties	0			
AEFD uterus	Kitchen – living	Negative Ranks	1	48.00	-6.383	**<0.001**
		Positive Ranks	59	30.20		
		Ties	0			
Conc. radon	Kitchen – living	Negative Ranks	1	48.00	-6.383	**<0.001**
		Positive Ranks	59	30.20		
		Ties	0			
Living ELCR	Kitchen – living	Negative Ranks	1	48.00	-6.383	**<0.001**
		Positive Ranks	59	30.20		
		Ties	0			

Wilcoxon Signed Rank test

Table 6 difference among participants' organs in living room

AEFD in organs	Mean Rank	Chi-square	*p* value
Bladder	1.00	238.559	< 0.001
Gonads	5.00		
Uterus	2.98		

Friedman test

Table 7 difference among participants' organs in kitchen room

AEFD in organs	Mean Rank	Chi-square	*p* value
Bladder	1.00	233.196	< 0.001
Gonads	5.00		
Uterus	2.96		

Friedman test

Table 8 Evaluation indoor air radon concentration in living room and kitchen with excess life time cancer risk (ELCR) in dwelling in Kurdistan Iraqi region-Sulaymania

N	**Location**	**Con. of radon in living room (Bq m^{-3})**	**ELCR (MPY^{-1}) in living room**	**Con .of radon in kitchen (Bq m-^{3})**	**ELCR (MPY^{-1}) in kitchen room**
1	Eiskan	94.883	9.205	99.947	9.697
2	Khurmal	97.514	9.460	107.664	10.445
3	Chamchamal	99.766	9.678	105.546	10.239
4	Shekhan	101.519	9.848	123.534	11.985
5	Darbandikhan	103.431	10.033	125.429	12.169
6	Rzgary	114.374	11.096	124.457	12.074
7	Bakhteary	123.316	11.964	139.300	13.513
8	Reaea	123.863	12.016	130.973	12.707
9	Takea	134.861	13.082	137.195	13.309
10	Kalar	136.624	13.255	145.655	14.129
11	Khalakan	137.726	13.362	146.821	14.244
12	Bazean	140.791	13.659	143.231	13.894
13	Kfry	146.878	14.250	155.473	15.084
14	Sharawany	161.118	15.631	170.123	16.505
15	Zaraeen	168.726	16.366	172.476	16.732
16	Toymalek	170.105	16.501	181.158	17.579
17	Said sadiq	173.524	16.836	182.156	17.672
18	Penjween	186.119	18.056	193.157	18.739
19	khormal	211.281	20.497	231.651	22.474
20	Zargata	216.631	21.017	220.563	21.398
21	Bardarash	232.114	22.518	240.118	23.292
22	Mawat	242.155	23.492	263.101	25.525
23	Dukan	243.168	23.592	249.671	24.223
24	Qaladza	243.569	23.746	261.511	25.371
25	Halabjay taza	258.142	25.045	267.662	25.968
26	Rania	290.626	28.193	304.654	29.556
27	Mamostayan	326.034	31.727	329.136	31.931
28	Sulaymania	327.572	31.780	341.552	33.137
29	Arbat	343.091	33.286	353.754	34.321
30	Halabjay kon	357.832	34.715	360.112	34.938
Ave.		190.245	18.463	200.259	19.428

Table 9 Evaluation indoor air radon concentration in living room and kitchen with excess life time cancer risk(ELCR) in dwelling in Kurdistan Iraqi region- Erbil

N	Location	Con. of radon in living room (Bq m^{-3})	ELCR (MPY^{-1}) in living room	Con .of radon in kitchen (Bq m^{-3})	ELCR (MPY^{-1}) in kitchen
31	Shorsh	95.113	9.2259	97.886	9.4949
32	Kas-Nazan	98.644	9.5684	102.326	9.9256
33	Shaqlawa	99.896	9.6899	106.894	10.3687
34	Salahadden	100.533	9.7517	114.224	11.0797
35	Nazanen	109.521	10.6230	119.174	11.5598
36	Holy- Zatd	116.804	11.3290	124.479	12.0746
37	Kareat- Zanko	124.871	12.1120	129.973	12.6073
38	Nawato dw	125.563	12.1790	132.195	12.8229
39	Erbil Center	132.960	12.8970	136.387	13.2295
40	Khalefan	136.921	13.2810	140.231	13.6024
41	Rzgary	138.781	13.4610	142.643	13.8363
42	Aeen-Kawa	143.279	13.8980	148.855	14.4389
43	Saed -Taqan	148.121	14.3670	153.348	14.8747
44	Sarsang	162.765	15.7880	166.923	16.1915
45	Qshtapa	167.098	16.2080	174.156	16.8931
46	Makhmur	171.554	16.6400	180.258	17.4850
47	Shaqlawa	177.824	17.2480	187.776	18.2142
48	Haji-Omaran	190.179	18.4470	196.158	19.0273
49	Rawanduz	213.201	20.6800	224.383	21.7651
50	Barzan	224.656	21.7916	230.673	22.3752
51	Harer	233.324	22.6324	241.176	23.3940
52	Taq-Taq	239.231	23.2054	248.273	24.0824
53	Shekholla	244.667	23.7327	254.511	24.6875
54	Prdea	257.239	24.9521	262.591	25.4713
55	Ronaki	278.152	26.9807	265.162	25.7207
56	Koya	305.996	29.6816	323.431	31.3728
57	Barsren	320.691	31.1070	336.156	32.6071
58	Deana	329.234	31.9357	344.071	33.3748
59	Eiskan	346.671	33.6270	352.564	34.1987
60	Sedakan	358.552	34.7795	364.412	35.3479
Ave.		193.068	18.7276	200.043	19.4041

Table 10 The comparission of the indoor radon concentration in kichen and living room with other countries.

Location	Con. Bq m^{-3}	Con.Bq m^{-3}	Type of detector	References	
	Kitchen	Living room		Author	years
Nigeria		255	CR-39NTD	Obed	2011
Swazilad		162	CR-39 NTD	Farid	1992
India	82.29	40.10	HS71512 Radon gas detector	Kadam	2010
Pakistan		23	CR-39 NTD	Rafique	2011
Pakistan		62	CR-39 NTD	Rahman	2011
Pakistan		38-141	CR-39 NTD	Faheem	2007
Iraq	187.215	184.212	CR-39 NTD	Salih (This study)	2011