Measurement of Radon Concentration in South of Iraqi's Oil Fields by Using Solid State Nuclear Track Detectors (SSNTDs)

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Abstract

Level of radon concentration has been performed in south of Iraq's oil fields, at 72 well. A passive integrating radon discriminative monitor was used in this study. Both LR-115 type II and CR-39 plastic track detectors have been used for the measurement of radon concentration in the Crude oil samples. The investigation show great variability of radon concentration in each well. The highest value of radon concentration was observed in oil well number (119) in Al-Hammar field 993.4 $Bq.m^{-3}$, while the lowest value observed in oil well number (76) in Al-Rafidhya field 195.9 $Bq.m^{-3}$ .This variation in concentration of radon in the well have been discussed in this study.

Keywords: Radon, CR-39, LR-115 type II, , Activity ($Bq\ m^{-3}$), Oil field, Crude oil.

Introduction

Radon, which is a topic of public health concern, has been found to be a ubiquitous indoor air pollutant in homes to which all persons are exposed . Risk projections imply that radon is the second leading cause of lung cancer after smoking [Melloni et al., 2000; ICRP,1987]. A relationship between lung cancer and inhalation of radon and its progeny has been demonstrated [Lubin et al., 1997]. Radon-222 , a progeny of Uranium- 238 formed from the radioactive decay of ^{226}Ra, is a colorless, odorless, electrically uncharged noble but hazardous gas which is radioactive, emits alpha radiation and decays with a half life of 3.824 days. Radon is present in trace amounts almost everywhere (indoor and outdoor) on the earth, being distributed in the soil, the ground water and in the lower atmosphere. The concentration of radon in the atmosphere varies, depending on the place, time, and height above the ground and meteorological conditions [Nagy et al.,2009; Ramachandran and Sahoo, 2009]. When radon decays to form its progeny (^{218}Po and ^{214}Po), they can collect electro statically on tiny dust particles, water vapors, oxygen, trace gases in indoor air and other solid surfaces. These dust particles (aerosols) can easily be inhaled and attach to the bronchial epithelium, produce a high local radiation dose. Alpha radiation being densely ionizing (high LET) can induce DNA double strand breaks and the development of cancer [Griffiths et al., 2010]. It has been estimated that the radon, largely in homes, constitutes more than 50% of the dose equivalent received by general population from all sources of radiation, both naturally occurring and man-made. Radon is well established human carcinogen for which extensive data are available extending into the range of general population exposure. It is well known that exposure of population to high concentrations of radon and its daughters for a long period lead to pathological effects like the respiratory functional changes and the occurrence of lung cancer [BEIR, 1990].

Solid state nuclear track detectors (SSNTD) have been extensively used in this regard and almost all branches of science and technology [Al-Khalifa, 2005; Fleischer et al., 1975]. In the present study SSNTD technique based on determining detection efficiencies of the CR-39 and LR-115 type II, have been used for measuring alpha- particles due to radon and thoron series. The relevant ranges of the emitted α -particles in air and SSNTD utilized, were calculated by means of a TRIM program [Ziegler, 2007]. SSNTDs have been used to evaluate radon concentrations in the crude oil samples, which brought from oil fields of Al-Zubbier oil fields in the south of Iraq and to set a baseline data for these areas which would be of great help for radiological database of Iraq.

Al-Zubier oil field are divided into six major groups Al-Hammar –mashref field, Al-Zubbier field, Al-Zubier –mashref field, Al-Rafidhiya field , Al-Hammar field and Al-Twba field.

Study the radon activity in this oil fields is very important in order to know wither these crude oil containing radon concentration with permutable values or not.

Method of Study

One sample from each oil field have been collected. There are 72 samples, each sample placed in the bottom of closed cylindrical plastic container of 10 cm height. The hight of crude oil in the container was 1cm as shown in the Fig.(1) [Misdaq and Satif, 1996].

Identical 1x1.5 cm of CR-39 and LR-115 type II SSNTDs have been separately placed at a distance of 9 cm above the sample for one month. Two identical films of CR-39 and same from LR-115 type II are used for each sample to get high accuracy. This long time of irradiation is necessary to accumulate considerable number of tracks of α -particles that emitted from radon, thoron and their progenies.

After the irradiation, the exposed films were developed in an NaOH solution with chemical etching conditions 2.5 N at 60 ^{o}C for 2 hr for LR-115 type II films and 6.25 N at 70 ^{o}C for 7 hr for CR-39 films. After the chemical treatment of CR-39 and LR-115 type II detectors [Misdaq and Satif, 1996], the visual counting of alpha particles tracks N_G^{CR} (number of tracks on CR detector, N_G^{LR} (number of tracks on LR detector) are carried out by means of an optical microscope.

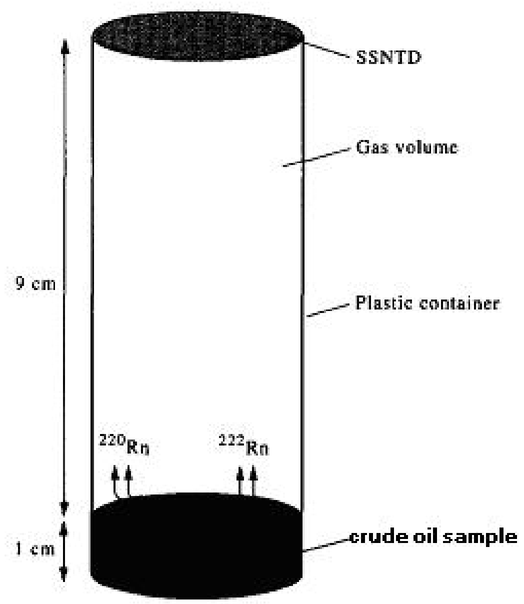

Fig.(1):Arrangement of the solid state nuclear track detector films placed at a distance of 9 cm above an oil sample in a cylindrical plastic container of 2 cm radius[Misdaq and Satif, 1996].

The global alpha particle track densities that registered on CR-39 and LR-115 detectors (i.e. ρ_G^{CR} and ρ_G^{LR}) are calculated according to the following equations

$$\rho_G^{CR} = \frac{N_G^{CR}}{A_G \times t_G} \quad \text{……….(1)}$$

And

$$\rho_G^{LR} = \frac{N_G^{LR}}{A_G \times t_G} \quad \text{……… (2)}$$

Where A_G is the global area of view and t_G is the global time of irradiation.

Hence, the global density of tracks due to the α-particles emitted by radon, thoron and their daughters, registered on the CR-39 SSNTD is then [Misdaq et al,, 1997]

$$\rho_G^{CR} = A_c^{222}\left(Bq.\ cm^{-3}\right)\left[\sum_{i=1}^{3} k_i\ P_i^{CR}\ R_i + \frac{A_c^{220}}{A_c^{222}}\ \sum_{i=1}^{4} k_i\ P_i^{CR}\ R_i\right] \quad \text{……..……….. (3)}$$

Where A_c^{220} and A_c^{222} is the activity concentration of thoron and radon respectively, k_i is the branching ratio in % , P_i^{CR} represents the probability for an alpha-particle of energy $E_{\alpha i}$ and index i emitted at a distance x from the detector to reach and be registered on the CR-39 SSNTD [Misdaq et al,, 1997], R_i is the range of the α-particle of energy $E_{\alpha i}$ and index i in the gas volume.

The global density of tracks per unit time (tracks.cm^{-2}.s^{-1}) due to the α-particles of the radon and thoron groups registered on the LR-115 type II SSNTD is then equal to [Misdaq et al,, 1997]:

$$\rho_G^{LR} = A_c^{222}\left(Bq.\ cm^{-3}\right)\left[3\ P^{LR}\ \Delta R + 4P^{LR}\ \Delta R \frac{A_c^{220}}{A_c^{222}}\right] \quad \text{………..…….. (4)}$$

Where P^{LR} represents the probability for an emitted α-particle to reach and be registered on the LR-115 SSNTD.

Combining eqs.(3) and (4), the following relationship between track densities and thoron to radon ratio is [Misdaq et al,, 1997]:

$$\frac{\rho_G^{CR}}{\rho_G^{LR}} = \frac{\sum_{i=1}^{3} k_i \; P_i^{CR} \; R_i + \frac{A_c^{220}}{A_c^{222}} \sum_{i=1}^{4} k_i \; P_i^{CR} \; R_i}{3 \; P^{LR} \; \Delta R + 4 \; P^{LR} \; \Delta R \; \frac{A_c^{220}}{A_c^{222}}} \quad \text{…. ………… (5)}$$

The values of P_i^{CR} for each index i are shown in Table (1) and the values of P^{LR} for each residual thickness are shown in Table (2).

Table (1): Data obtained for the probability (P_i^{CR}) for radon group α-particles and thoron group α-particles to be registered on the CR-39 SSNTD for the gas volume of the α-particles of energy Eα i and index i in the gas volume [Misdaq and Satif, 1996].

Nuclide	$E_{\alpha i}$, MeV	R_i , cm	$P_i^{CR} \times 10^{-3}$
Radon group α-particles			
^{222}Rn	5.49	3.90	2.871
^{218}Po	6.00	4.65	3.383
^{214}Po	7.68	6.65	4.440
Thoron group α-particles			
^{220}Rn	6.28	4.80	3.391
^{216}Po	6.78	5.45	3.433
^{212}Bi	6.08	4.75	3.527
^{212}Po	8.78	8.36	5.711

Table (2): Values of the probability (P^{LR}) for the α-particles of the radon and thoron groups to be registered on the LR-115 SSNTD for different residual thickness for (LR-115 films) for the gas volume of the water samples. R_{min} and R_{max} are the α-particles ranges in the gas volume which correspond to the lower and upper ends of the energy window[Misdaq and Satif, 1996].

Residual thickness, μm	R_{min} , cm	R_{max} , cm	$P^{LR} \times 10^{-3}$
3	0.46	3.83	203.299
4	0.61	3.52	11.302
5	0.80	3.44	4.329
6	0.98	2.71	1.536

7	**1.07**	**2.66**	**1.405**
8	**1.29**	**2.53**	**1.336**
9	**1.42**	**2.31**	**0.267**
10	**1.60**	**2.02**	**0.191**

Knowing ρ_G^{CR} , ρ_G^{LR} , P_i^{CR} and P^{LR} one can determine the A_c^{220}/A_c^{222} ratio and consequently the thoron A_c^{220} and radon A_c^{222} activities of the studied sediment samples have been evaluated.

Results and discussion

The A_c^{220}/A_c^{222} ratios as well as radon activity per unit volume for the samples studied have been determined by using Eqs (3), (4) and (5). The error on track density counting is smaller than 7 % for samples studied. All the oil wells of Al- Zubier oil fields have been studied to measure the radon activity, each one of oil wells was taken as station. Table (3) shows the name of filed is refer to the field where the well lies, well's number as a name of station, and the global track density of LR-115 type II (ρ_G^{LR}), the global track density of CR-39 (ρ_G^{CR}), the ratio of A_c^{220}/A_c^{222} and the activity of Radon-222 (A_c^{222}).

Table (3): The radon concentration in the crude oil samples of Al-Zubier fields in the south of Iraq.

Station Number	***Name of Field***	***Name Of Station (Wells' Number)***	$\rho_G^{LR}\times10^{-5}$ ***(tr .cm $^{-2}$.s $^{-1}$)***	$\rho_G^{CR}\times10^{-5}$ ***(tr .cm $^{-2}$.s $^{-1}$)***	A_c^{220}/A_c^{222}	A_c^{222} ***(Bq.m^{-3})***
1	Al-Hammar-Mashref	60	4.472792	7.156466	0.9329	581.3917
2	Al-Hammar-Mashref	78	4.472792	7.200754	0.7188	666.0977
3	Al-Hammar-Mashref	79	3.946581	6.314528	0.9329	512.9926
4	Al-Hammar-Mashref	80	4.209687	6.735498	0.9329	547.1922
5	Al-Hammar-Mashref	89	4.209687	6.735498	0.9329	547.1922
6	Al-Hammar-Mashref	90	4.209687	6.735498	0.9329	547.1922
7	Al-Hammar-Mashref	116	3.42037	5.506505	0.5531	574.1441
8	Al-Hammar-Mashref	166	3.265407	5.227754	0.8852	436.8189
9	Al-Hammar-Mashref	168	4.209687	6.735498	0.9329	547.1922
10	Al-Hammar-Mashref	31	4.018962	6.430338	0.9329	522.401

11	Al-Hammar-Mashref	100	3.767777	6.028441	0.9329	489.7509
12	Al-Hammar-Mashref	107	3.660509	5.856814	0.9329	475.8079
13	Al-Hammar-Mashref	28	2.260666	3.707401	0.0271	636.3518
14	Al-Hammar-Mashref	32	3.265407	5.224649	0.9329	424.4508
15	Al-Hammar-Mashref	69	2.009481	3.275296	0.1479	489.5347
16	Al-Hammar-Mashref	159	2.763036	4.448252	0.5531	463.8038
17	Al-Hammar-Mashref	161	3.265407	5.257026	0.5531	548.1318
18	Al-Zubier-Mashref	13	2.009481	3.235093	0.5531	337.3119
19	Al-Zubier-Mashref	53	1.507111	2.418764	0.7188	224.4421
20	Al-Zubier-Mashref	139	1.758296	2.813272	0.9329	228.5504
21	Al-Zubier-Mashref	147	2.104843	3.367749	0.9329	273.5961
22	Al-Zubier-Mashref	150	1.841738	2.983461	0.3132	378.9124
23	Al-Zubier-Mashref	22	1.963457	3.147397	0.7976	277.5286
24	Al-Zubier-Mashref	36	1.138056	1.854941	0.1479	277.2445
25	Al-Zubier-Mashref	53	1.315527	2.144205	0.1479	320.4788
26	Al-Zubier-Mashref	127	1.707083	2.748259	0.5531	286.5514
27	Al-Zubier-Mashref	158	1.841738	2.957712	0.6824	281.2513
28	Al-Zubier-Mashref	170	2.367949	3.812195	0.5531	397.4843
29	Al-Zubier-Mashref	171	1.315527	2.117886	0.5531	220.8246
30	Al-Zubier-Mashref	21	1.841738	2.983461	0.3132	378.9124
31	Al-Zubier-Mashref	156	1.052422	1.704835	0.3132	216.5214
32	Al-Zubier-Mashref	157	1.315527	2.117886	0.5531	220.8246
33	Al-Zubier-Mashref	160	1.052422	1.715364	0.1479	256.383
34	Al-Zubier-Mashref	163	2.511851	4.018961	0.9329	326.5006
35	Al-Zubier	3	1.578632	2.573047	0.1479	384.5746
36	Al-Zubier	5	2.845139	4.580431	0.5531	477.5856
37	Al-Zubier	29	1.578632	2.541464	0.5531	264.9896
38	Al-Zubier	35	1.841738	2.983461	0.3132	378.9124
39	Al-Zubier	115	2.104843	3.367749	0.9329	273.5961
40	Al-Zubier	139	1.315527	2.131043	0.3132	270.6517
41	Al-Zubier	56	1.841738	2.959485	0.6477	288.2271
42	Al-Zubier	67	1.44708	2.344148	0.3132	297.7169
43	Al-Zubier	112	2.104843	3.388618	0.5531	353.3194
44	Al-Zubier	126	1.973291	3.168977	0.6824	301.3407
45	Al-Zubier	8	2.243951	3.590321	0.9329	291.6779
46	Al-Zubier	9	1.536375	2.473433	0.5531	257.8962
47	Al-Zubier	10	2.367949	3.788717	0.9329	307.7956
48	Al-Zubier	14	1.710185	2.753252	0.5531	287.072
49	Al-Zubier	85	2.104843	3.367749	0.9329	273.5961
50	Al-Rafidhya	38	2.894159	4.63637	0.8402	398.1185
51	Al-Rafidhya	58	1.710185	2.787467	0.1479	416.6225
52	Al-Rafidhya	65	2.009481	3.255191	0.3132	413.4233
53	Al-Rafidhya	70	2.009481	3.215169	0.9329	261.2005
54	Al-Rafidhya	76	1.507111	2.411377	0.9329	195.9004
55	Al-Rafidhya	78	1.281044	2.075184	0.3132	263.5573
56	Al-Rafidhya	66	1.758296	2.813272	0.9329	228.5504
57	Al-Rafidhya	71	2.260666	3.63948	0.5531	379.4759
58	Al-Rafidhya	109	1.507111	2.411377	0.9329	195.9004
59	Al-Rafidhya	167	1.758296	2.813272	0.9329	228.5504

60	Al-Rafidhya	172	2.009481	3.215169	0.9329	261.2005
61	Al-Hammar	18	3.767777	6.103482	0.3132	775.1686
62	Al-Hammar	30	4.521332	7.23413	0.9329	587.7011
63	Al-Hammar	119	4.078134	6.647037	0.1479	993.4843
64	Al-Hammar	121	3.840938	6.221996	0.3132	790.2204
65	Al-Hammar	124	4.209687	6.756501	0.71888	626.9155
66	Al-Hammar	147	3.025712	4.90163	0.31325	622.499
67	Al-Hammar	148	3.104644	4.967429	0.93290	403.5542
68	Al-Hammar	51	3.315128	5.370481	0.31325	682.0423
69	Al-Hammar	109	3.065178	4.934902	0.55316	514.5214
70	Al-Twba	1	3.315128	5.304204	0.93290	430.9138
71	Al-Twba	2	2.104843	3.40967	0.3132	433.0428
72	Al-Twba	5	1.315527	2.131043	0.3132	270.6517

From Table(3) it is clear that the observed the concentration of radon in oil in Al-hammar field ,well number 119 (station 63) , has the highest value 993.4843 Bq m^{-3} while the lowest value 195.9 Bq m^{-3} of activity of Radon in Al-Rafidhya, well number 76 (station 54).

Fig.(3) shows the Radon concentration of the oil samples of Al-Zubier fields in the south of Iraq as a function of station number. From the values in Fig.(3) one can observe that the radon activity in all stations of Al-Zubier fields are within the natural limits [ICRP, 1987].

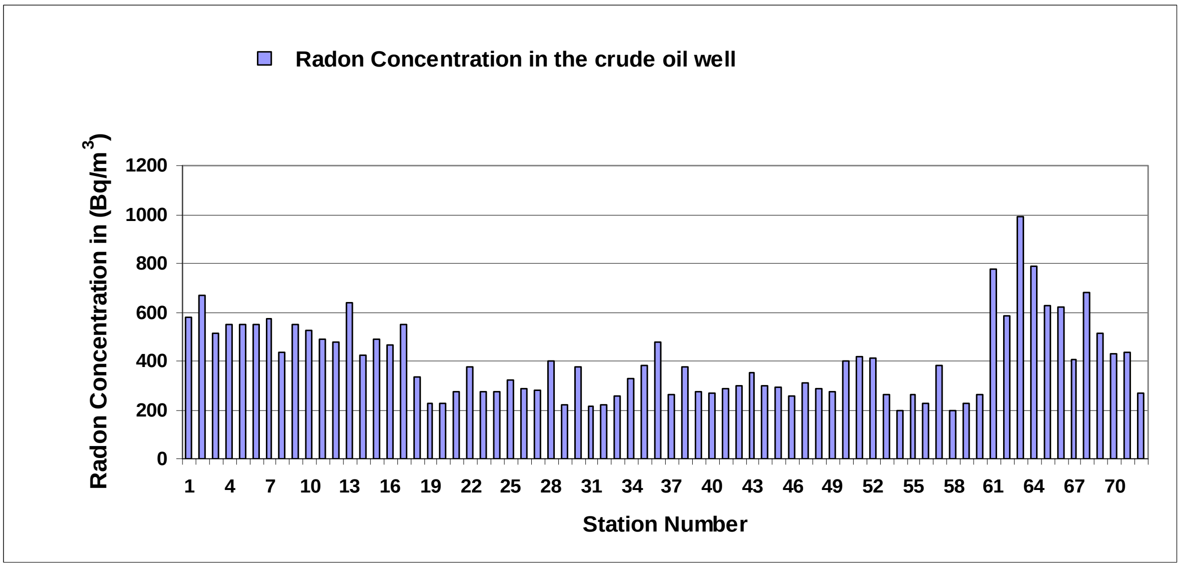

Fig.(3): The Radon concentration of the crude oil samples of Al-Zubier fields in the south of Iraq.

From this figure, we can easily observe that the wells of Al-hammar field have the higher concentration of radon while Al-Rafidhiya field have the lowest values .

This figure reflects great variability of radon concentration in each station, showing many parameters may be effect on these results. One of these parameters is due to the geological structure of the oil well, when the soil or rocks of these well contents of radium and uranium are high, the radon concentration was increased . The uranium concentration measurement in the anomalous areas are in progress.

Conclusion

To conclude, the activity of radon levels have been measured in the south of Iraqis oil fields. This investigations shows the maximum concentration of radon in oil in Al-Hammar field ,well number 119 (station 63) , has value 993.4843 Bq m^{-3} , while the lowest value 195.9 Bq m^{-3} of activity of radon in Al-Rafidhya, well number 76 (station 54).

It may be mentioned here that Iraq has variable geologies, it is therefore suggested that an extensive study of uranium and thorium concentration in sediments throughout the fields must be initiated. determination of the seasonal variations in the radon concentration levels is also necessary to be carried out.

Despite the limitation of existing data the observational and experimental data presented here is the first investigation and study provided a basis for the radon map in Iraq.

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قياس تركيز غاز الرادون في حقول النفط الخام جنوب العراق باستخدام الكواشف الصلبة للاثار النووية (SSNTDs)

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الخلاصة

لقد تناولت هذه الدراسة تركيز غاز الرادون في حقول نفط جنوب العراق الى 72 بئرا. اعتمدت في هذه الدراسه طريقة القياس الطويلة الامد لانبعاث جسيمات الفا باستخدام كواشف الاثر النووية الصلبة (SSNTDs) من نوع LR-115 type II و CR-39 واستخدام طريقة الاسطوانة المغلقة لقياس تركيز الرادون والثورون لنماذج من النفط الخام في جنوب العراق. اثبتت الدراسة بان هناك فرق كبير في تركيز الرادون للابار التي تم قياس تركيز لها. وان هناك عدة عوامل قد تكون السبب في هذا الفرق في تركيز الرادون بين بئر واخر ،اعلى قيمة وجدت في حقل الحمار للبئر رقم (119) والبالغة 993.4 $Bq.m^{-3}$ بينما اقل قيمة لتركيز الرادون كانت في حقل الرافضية للبئر (76) وكانت 195.95 $Bq.m^{-3}$. نوقشت احتمالية بعض الاسباب التي ادت الى هذا التباين في قياس تركيز الرادون بين بئر واخر.