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Measurement of Radon Exhalation Rate from Core of some Oil -Wells in Basra Governorate in the Southern Iraq

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ABSTRACT

Naturally occurring radioactive Radon gas concentrations in the oil-well core as tracer for Naturally Occurring Radioactivity Materials (NORM) were measured in different locations of oil-field in Basra governorate. Two types of Solid State Nuclear Track Detectors were used in the measurements which are CR-39 and LR-115 type-II. The core samples were collected from different depths of ten wells. The number of core samples was 100 which were kept in plastic containers. The maximum radon concentration was 42485 Bq/m^3 in well core ID:Ru-277(F2) and minimum concentration was 1223Bq/m^3 in well core ID: WQ-31(F6) The arithmetic average radon concentration was 19220 Bq/m^3 for maximums and for minimums average was 6504 Bq/m^3.

Keywords: Pollution, Oily-core, Radioactive, Radon, Solid State, Nuclear Track Detectors.

INTRODUCTION

Environmental pollution is a global problem resulting from industrial, agricultural and military activities. More than half of the radiation dose of natural origin of the pollution originates from radon [1-4]. Pollution caused by oil production and its derivatives is one of the most prevalent problems in the work of oil field and present a challenge in caring for environment [5-8]. Many accidents can cause environmental oil pollutions; among them is the spread of radioactive contamination which can seriously threaten human health [9]. Radio nuclide's in the ^{238}U decay series is one of three natural radioactive decay series, including ^{226}Ra, the parent of radon occur in trace amounts throughout earth's crust with varying degrees of concentration. Radon gas, contains mostly ^{222}Rn (radioactive with half life 3.8 day) and ^{220}Rn (radioactive also with half life 55.6 s), is a chemically inert and very mobile gaseous and it is a daughter of uranium ^{238}U which is found in all rocks and soils and presents in all dwelling with different concentration [10].

Compared with artificial radioactive sources, the activity level found in NORM is not large, even when elevated in oil and gas production and processing. The potential hazard lies in the enormous quantity generated. In oil fields of Basra, there is now a renewed interest and focus on the regulation of radioactivity in NORM, and the oil industry is the most important section of the economy. During drilling procedure a mixture of oil, gas, formation water, production water, sludge, scale, mud and well-core are pushed to the surface and all of them contaminated with NORM in different scale [8,9]. The EPA estimate that oil gas activities generate approximately a million of NORM waste each year; most of the waste currently in being stored until disposal guide line are developed [11]

In the present investigations, the passive technique of Solid State Nuclear Track Detectors (SSNTD's), have been utilized for the comparative study of the oil-well core radon gas level in Basra oil fields. Two kinds of detectors were used in the investigation, CR39 and LR115-II, during the currently conducted study because of their simplicity and long – term integrated read out, high sensitivity to alpha-particles radiation ruggedness, ease of handling and low cost. The principle of this technique is based on the production of track in the detector due to alpha particles emitted from radon and its progeny.

MATERIALS AND METHODS

A core is a sample of rock having the shape of cylinder, shown in Figure-1(left part), which is taken from the side of a drilled oil or gas well located in the southern-west of Basra Governorate in Iraq, as shown in figure-2. Samples of core were collected from different depths of the oil-well, 100 m to 3250 m. From each well 10 samples were collected. The total number of samples was 100. For radon concentration measurements, part of the core grinded, sieved by 200 μm pores and dried to 110 ^{o}C.

Each sample from the core is placed in the bottom of the closed plastic cylinder container to occupy 1cm height from 10 cm height of the cylinder, diameter 4 cm (shown in figure-1, right part)[12]. Identical shaped CR-39 and LR-115 type II SSNTDs (1.5cm×1.5cm) have been separately placed at a distance 9 cm above the sample for three months [13]. Two identical films of CR-39 and LR-115 type II are used for each sample to get a high accuracy.

Figure-1. Two cylindrical samples of oil-well core were taken from the drillers and the sample container for irradiate the detectors.

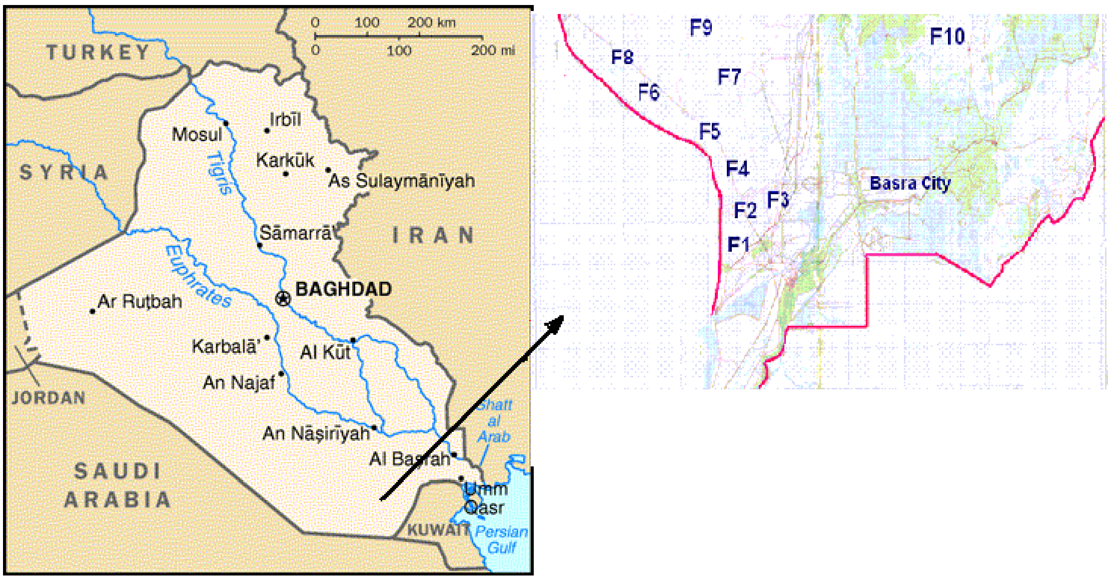

Figure-2. Map of Iraq and locations of oil field wells in Basra Governorate.

The long time of irradiation is necessary to accumulate considerable number of tracks of α-particles that emitted from radon. After the irradiation, the exposed films were developed in an NaOH solution for chemical etching conditions 2.5N at 60C for 120 minutes for LR-115 type II films and 6.25N at 70C for 7 hours for CR-39 films[14]. The normality (N) of NaOH solution is calculated by using the following equation.

$$N = \frac{W(g)}{V} \times \frac{1000}{M_W}$$

(1)

Where W(g) is a mass of solid NaOH in grams.
V is the distilled water volume in mL.
M_w is the molecular weight of NaOH which is equal to 40.

After the chemical treatment of the CR-39 and LR-115 type II detectors, the visual counting of alph particles tracks are carried out by means of an optical microscope 400X.

The global alpha particle track densities that registered on CR-39 and LR-115 detectors are calculated according to the following equations [14-16]:

$$\rho_G^{CR} = A_c^{222}(Bq.cm^{-3})\left[\sum_{i=1}^{3} k_i\, P_i^{CR}\, R_i + \frac{A_c^{220}}{A_c^{222}} \sum_{i=1}^{4} k_i\, P_i^{CR}\, R_i\right] \quad (2)$$

And

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

where A^{222} and A^{220} are radon and thoron concentration, P_i^{CR} the probability of alpha-particle of energy E_α (tabulated), R_i is the range of alpha particle in the detector material, and k_i is the branching ratio for alpha decay of radon (tabulated)

Dividing equation (2) on (3) we get

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

Measuring ρ_G^{CR} , ρ_G^{LR} and make use of P_i^{CR}, P_i^{LR} values, one can calculate the $^{220}A/^{222}A$ ratio from the fallowing;

$$\frac{A_c^{220}}{A_c^{222}} = \frac{\sum_{i=1}^{3} k_i\, P_i^{CR}\, R_i - 3P^{LR}\,\Delta R\,\frac{\rho_G^{CR}}{\rho_G^{LR}}}{4P^{LR}\,\Delta R\,\frac{\rho_G^{CR}}{\rho_G^{LR}} - \sum_{i=1}^{4} k_i P_i^{CR} R_i} \quad \textbf{(5)}$$

Using relations (5), (2) and (3) one can evaluate the activity of Radon ^{222}A and thoron ^{220}A.

RESULTS AND DISCUSSION

The concentrations of Radon $^{222}A_c$ activity together with the $^{220}Ac/^{222}$ Ac ratio are listed in tables (1-10). From these tables on can recognize that station number (S9) in table-2 has the highest radon concentration in 42485 Bq/m^3, at 3000 m depth in Ru-277(F2) well, while, lowest radon concentration is 1123 Bq/m^3 located in table- 6 at WQ-

31(F6) at depth 100 m from the ground. In table-11 we represent the average radon concentration for each well is presented and it is found that the highest one in F2 well at southern Rumaila, which is equal to 19220 Bq/m^3. From the tables, one can see that the radon concentrations, which reflect the present of NORM, is often high in the core and this may brought to the surface via drilling operation. This concentration is technically (human) enhanced naturally occurring radioactive material called TNORM.

Table 1. The radon concentrations in well core ID: Ru-278 (F1)

Sample No.	Depth	$\rho_G^{CR} x10^{-3}$ $Tr/cm^2.Sec$	$\rho_G^{LR} x10^{-3}$ $Tr/cm^2.Sec$	$^{220}A_c/^{222}A_c$	A_c^{222}
S1	100	2.92012	1.81696	0.63951	8603
S2	500	2.92012	1.81696	0.63951	8603
S3	1500	2.46588	1.55739	2.49083	10512
S4	1750	2.27120	1.42761	1.526029	13720
S5	2000	1.36272	0.84359	0.41707	15905
S6	2250	2.59566	1.62229	0.92695	21162
S7	2500	1.68718	1.03826	0.22280	23347
S8	2750	3.24458	2.01164	0.47085	36044
S9	3000	3.24458	2.01164	0.47085	36044
S10	3250	1.36272	0.84359	0.41707	15905

Table 2. The radon concentrations in well core ID:Ru-277(F2)

Sample No.	Depth	$\rho_G^{CR} x10^{-3}$ $Tr/cm^2.Sec$	$\rho_G^{LR} x10^{-3}$ $Tr/cm^2.Sec$	$^{220}A_c/^{222}A_c$	A_c^{222}
S1	100	0.51913	0.32432	0.92645	4112
S2	500	0.51913	0.32445	0.92695	4232
S3	1500	1.03826	0.64891	0.92695	8464
S4	1750	2.46588	1.43739	2.23083	9512
S5	2000	0.84359	0.23913	0.11280	10273
S6	2250	0.84359	0.51913	0.22280	11673
S7	2500	2.07653	1.29783	0.92566	16929
S8	2750	3.56904	2.20631	0.35986	39485
S9	3000	3.56904	2.20631	0.35986	42485
S10	3250	3.24458	2.01164	0.47085	35044

Table 3. The radon concentration in well core ID: Rt -11(F3)

Sample No.	Depth	$\rho_G^{CR} x10^{-3}$ $Tr/cm^2.Sec$	$\rho_G^{LR} x10^{-3}$ $Tr/cm^2.Sec$	$^{220}A_c/^{222}A_c$	A_c^{222}
S1	100	0.19467	0.12970	1.6347	3208
S2	500	2.92012	1.81696	0.63951	8603
S3	1500	2.92012	1.81696	0.63951	8603
S4	1750	0.84359	0.51913	0.22280	11673
S5	2000	1.36272	0.84359	0.41707	15905
S6	2250	2.07653	1.29783	0.92566	16929
S7	2500	2.59566	1.62229	0.92695	21162
S8	2750	2.59566	1.62229	0.92695	21162
S9	3000	1.68718	1.03826	0.22280	23347
S10	3250	1.16804	0.71380	0.06889	19114

Table 4. The radon concentration in well core ID: Tu-3(F4)

Sample No.	Depth	$\rho_G^{CR} x10^{-3}$ $Tr/cm^2.Sec$	$\rho_G^{LR} x10^{-3}$ $Tr/cm^2.Sec$	$^{220}A_c/^{222}A_c$	A_c^{222}
S1	100	0.19467	0.12970	1.6347	3208
S2	500	0.19467	0.12970	1.6347	3208
S3	1500	0.19467	0.12970	1.6347	3208
S4	1750	0.19467	0.12970	1.6347	3208
S5	2000	0.51913	0.32445	0.92695	4232
S6	2250	0.51913	0.32445	0.92695	4232
S7	2500	1.03826	0.64891	0.92695	8464
S8	2750	0.84359	0.51913	0.22280	11673
S9	3000	1.36272	0.843591	0.41017	15905
S10	3250	1.68718	1.038266	0.22280	23347

Table -5. The radon concentration in well core ID: R-7 (F5)

Sample No.	Depth	$\rho_G^{CR} x10^{-3}$ $Tr/cm^2.Sec$	$\rho_G^{LR} x10^{-3}$ $Tr/cm^2.Sec$	$^{220}A_c/^{222}A_c$	A_c^{222}
S1	100	0.19467	0.12970	1.6347	3208
S2	500	0.51913	0.32445	0.92695	4232
S3	1500	0.51913	0.32445	0.92695	4232
S4	1750	2.92012	1.81696	0.63951	8603
S5	2000	0.84359	0.51913	0.22280	11673
S6	2250	1.36272	0.843591	0.41017	15905
S7	2500	2.59566	1.62229	0.92695	21162
S8	2750	1.68718	1.03826	0.22280	23347
S9	3000	3.24458	2.01132	0.45042	34043
S10	3250	2.59566	1.62229	0.92695	21162

Table 6. The radon concentration in well core ID: WQ-31(F6)

Sample No.	Depth	$\rho_G^{CR} x10^{-3}$ $Tr/cm^2.Sec$	$\rho_G^{LR} x10^{-3}$ $Tr/cm^2.Sec$	$^{220}A_c/^{222}A_c$	A_c^{222}
S1	100	0.19231	0.12530	1.6132	1123
S2	500	0.19453	0.12430	1.6121	2346
S3	1500	0.19467	0.12970	1.6347	3208
S4	1750	0.19467	0.12970	1.6347	3208
S5	2000	0.51913	0.32445	0.92695	4232
S6	2250	0.51913	0.32445	0.92695	4232
S7	2500	2.92012	1.81696	0.63951	8603
S8	2750	2.27120	1.42761	1.526029	13720
S9	3000	1.36272	0.84359	0.41707	15905
S10	3250	1.03826	0.64891	0.92695	8464

Table 7. The radon concentration in well core ID: Zb-110(F7)

Sample No.	Depth	$\rho_G^{CR} x10^{-3}$ $Tr/cm^2.Sec$	$\rho_G^{LR} x10^{-3}$ $Tr/cm^2.Sec$	$^{220}A_c/^{222}A_c$	A_c^{222}
S1	100	0.19467	0.12970	1.6347	3203
S2	500	2.92012	1.81696	0.63951	8403
S3	1500	2.92012	1.61464	0.62531	8603
S4	1750	0.84359	0.51913	0.22280	11673
S5	2000	2.07653	1.29783	0.92566	16929

S6	2250	2.07653	1.29783	0.92566	16929
S7	2500	2.07653	1.13789	0.82452	17547
S8	2750	2.59566	1.62229	0.92695	21162
S9	3000	2.07653	1.29783	0.92566	16929
S10	3250	2.07653	1.11358	0.72160	16536

Table 8. The radon concentration in well core Lu-22(F8)

Sample No.	Depth	$\rho_G^{CR} x10^{-3}$ $Tr/cm^2.Sec$	$\rho_G^{LR} x10^{-3}$ $Tr/cm^2.Sec$	$^{220}A_c/^{222}A_c$	A_c^{222}
S1	100	0.19467	0.12970	1.6347	2208
S2	500	0.51913	0.32445	0.92695	4232
S3	1500	1.03826	0.64891	0.92695	8464
S4	1750	0.84359	0.51913	0.22280	11673
S5	2000	2.27120	1.41761	1.516029	13613
S6	2250	2.27120	1.42761	1.526029	13720
S7	2500	1.68718	1.03826	0.22280	23347
S8	2750	4.54241	2.85521	1.52673	27442
S9	3000	4.54241	2.85521	1.52673	27442
S10	3250	2.59566	1.62229	0.92695	21162

Table 9. The radon concentration in well core ID: NR-13(F9)

Sample No.	Depth	$\rho_G^{CR} x10^{-3}$ $Tr/cm^2.Sec$	$\rho_G^{LR} x10^{-3}$ $Tr/cm^2.Sec$	$^{220}A_c/^{222}A_c$	A_c^{222}
S1	100	0.51913	0.31445	0.61695	2232
S2	500	0.51913	0.32445	0.92695	4232
S3	1500	2.92012	1.81696	0.63951	8464
S4	1750	0.12978	0.06489	0.61671	10649
S5	2000	0.84359	0.51913	0.22280	11673
S6	2250	0.12978	0.06489	0.61671	10989
S7	2500	0.12978	0.06489	0.61671	10649
S8	2750	2.27120	1.42761	1.526029	13720
S9	3000	2.27120	1.42761	1.526029	13720
S10	3250	2.92012	1.81696	0.63951	8464

Table 10. The radon Concentration in Well core ID: Zb-122(F10)

Sample No.	Depth	$\rho_G^{CR} x10^{-3}$ $Tr/cm^2.Sec$	$\rho_G^{LR} x10^{-3}$ $Tr/cm^2.Sec$	$^{220}A_c/^{222}A_c$	A_c^{222}
S1	100	0.51532	0.31335	0.72695	1232
S2	500	0.51913	0.31223	0.91436	3132
S3	1500	1.03826	0.64891	0.92695	8464
S4	1750	2.46588	1.55739	2.49083	10512
S5	2000	0.84359	0.51913	0.22280	11673
S6	2250	0.84359	0.51913	0.22280	11673
S7	2500	2.07653	1.29783	0.92566	16929
S8	2750	1.68718	1.03632	0.21170	22347
S9	3000	4.54241	2.85523	1.52682	27441
S10	3250	4.54241	2.85523	1.52682	27341

Table-11. The average Radon concentrations in the ten locations of oil wells in Basrah Governorate

location	Average Radon concentration Bq/m^3
F1	15380
F2	19220
F3	14970
F4	8068
F5	14757
F6	6504
F7	13791
F8	15330
F9	9478
F10	14074

Figure-3, shows the radon concentration in the core with respect to the well depth. From the figure one can see that the concentration increases almost in quadratic shape, reaches its maximum at depth 3000m, then started to decrease at depth 3250m, as shown in the solid black bold line in the middle, which represent the arithmetic mean values. The depth 3250m is normally the oil aquifer depth and may be that; the crude oil washed up the ^{226}Ra (parent of ^{222}Rn) and effectively reduced radon concentration in the rocks. Also there is a dependence on the geological structure of the region.

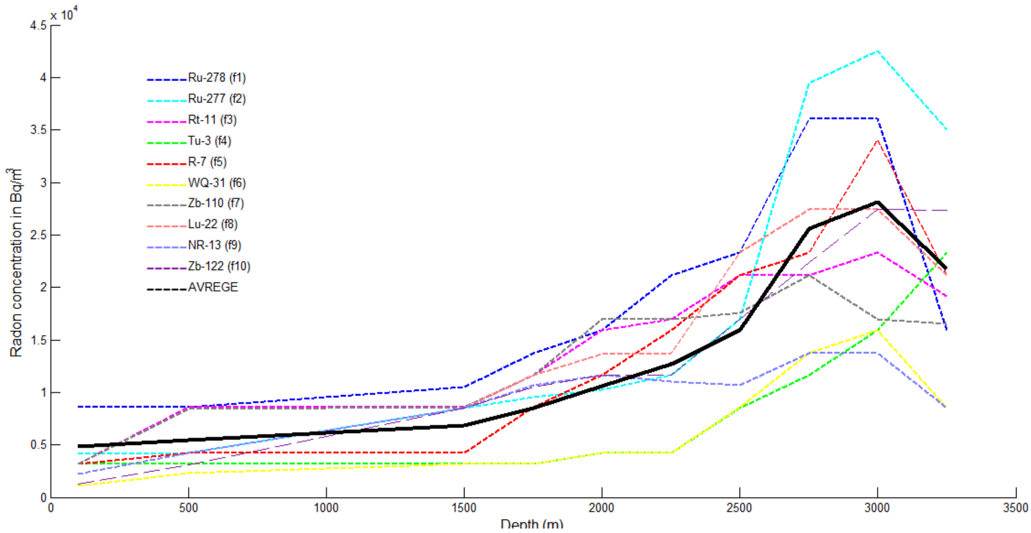

Figure-3. Radon concentration in wells core as a function of depht for 10 wells location. The black bold line represent the arethmatic average of the concentrations.

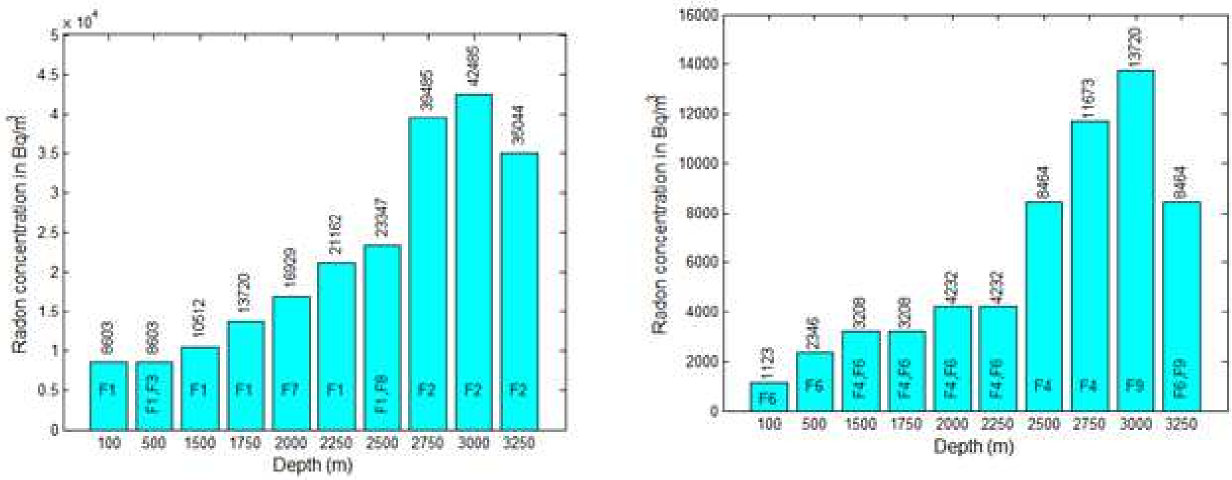

Figure-4. The maximum radon concentrations (on the left) related to the depth for all the location for all cores. The right side of the figure represent the minimum concentrations for all the wells core.

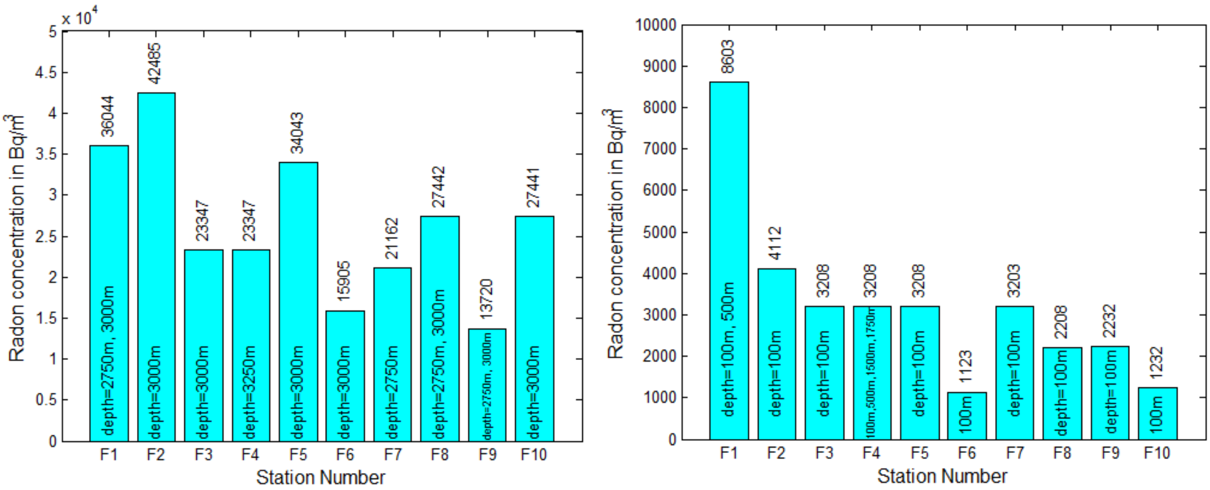

Figure-5. The maximum radon concentrations (on the left) related well ID and on the right we represent the minimum concentration.

Figure-4; represent the maximum concentration (left) and minimum concentration (right) taken in a certain depth. From the maximum concentration it appears that well ID:F1 dominates the distributions; it has maximum in six depths (100,500,1500,2250,2500 m), while well ID:F2 has highest maximum in three depths specially at high depth (2750, 3000, 3250 m). In the right part of the figure, which contain a bar chart for the minimum concentration relative the depth, one can see that well ID:F4 has minimum concentration in six depth and lowest minimum found in ID:F6 well. In figure-5; we represent bar cod drawing for the maximum radon concentration in relative location ID (F1 –F10) on the left, and the minimum radon concentration on the right. It is clear that most of the maximums were at high depth (from 2500 to 3000 m)

CONCLUSION

Our measurements describe pretty well the region of Basra Governorate oil fields from radioactivity point of view. Because there are no standard values concerning radioactivity concentration in the core of wells, we compare our results with measurement of radon concentration in sludge, scale and production water. The radon concentrations in the oil well cores at Basrah governorate are greater than the natural background in the area. This high radon concentration may have influences on workers , contaminate the equipment of cleaning facilities and general public. The long time of irradiation is necessary to accumulate considerable number of tracks of α-particles that emitted from radon, thoron and their progenies

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