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Radon Concentration and the Annual Effective Dose in the Soil Samples of the Midland Refineries Company - Doura - Baghdad – Iraq

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Abstract: ***In this research, the CR-39 detector technique was used, to estimate the radon concentration from the soilinMidlandrefineriesCompany "Dourarefinery", Baghdad, Iraq.Radon concentrations and Annual Effective Doserate in soil samples have been measured by using solid state nuclear track detector type CR-39. Nine soil samples were collected from different areas within the Doura refinery and two soil samples were collected for areas outside the refinery for comparison. The results showed variable values for concentrations of radon gas and the effective dose rate.The average radon concentration were found to be 280.24 Bq/m^3 and annual effective dose rate 7.07 mSv/yin Doura refinery. For areas outside the refinery, the concentration of radon were 154.96 Bq/m^3. Annual effective dose rate 3.90 mSv/y. Theseresults were higher than the global limit.***

Keywords: Radon, Effective Dose Rate, CR-39.

1. Introduction

Radon (^{222}Rn) is generated by the spontaneous decay of the radium element ^{226}Ra in the earth's crust. The presence of radium in an area depends on the presence of uranium ^{238}U [1].The main sources of radon are soil and water, and about 80% of the radon that flows into the outer is produced from the upper layer of the earth. As a result, the presence of radium-226 and therefore uranium-238 is the reason for the release of radon in the soil and therefore vary from place to place according to the geological nature and is often concentrated in the granite and phosphate rocks[2,3] .Natural radioactivity in soil measurement is of great importance to many researchers around the world, The importance of soil in this regard is that it is the final destination of radioactive materials and its long-term role is to be a repository of radioactive materials and at the same time as a source of these substances in air, water, plant and human pollution [4]. Resultingin a nationwide survey over the past two decades, measuring natural radioactivity in the soil is very important to determine the amount of natural background change in activity with time or leakage [5].Normally dry soil shows a 2m propagation length, Wet soil shows 0.5m and wet soil of .05m. Radon along with her daughter's products are a major contributor to the public's exposure to natural radiation results are significant health risks,Heshort-lived daughters of radon are lung cancer factors [6]. The total effective dose has been reported for more than 50% [7], from this perspective, the measurement of natural radioactivity is very important for determining the amount of natural and industrial activities. These affect the release of radioactive elements to the monitoring environment any such release is important in the health assessment study.

Since radon is a colorless, odorless and tasteless gas it can be realized until some biological disturbances are manifested in living organisms. Radon decay products are very small solid particles that can be inhaled easily and can produce high-ionized alpha, beta or gamma radiation.The dense ion-ionizing particles emitted from short-term decay products deposited from radon can interact with biological tissues in the lungs and disrupt the DNA of these pulmonary cells[8-10].Damaged DNA is a sufficient potential leading to cancer. This DNA damage, associated with radon, can occur at any level of exposure because one alpha particle can damage the genetically modified cell [11]

The main objective of this research is to determine the level of concentration of radon in soil samples of different areas within the Midland RefineriesCompany(Doura refinery) and soil samples from the vicinity of the refinery for comparison. As well as the determination of the annual effective dose rate and the risk of lung cancer in people in these areas.

2. The Method of Work

The detector used in this research is the CR-39 track, which is an organic nuclear track detector (C12H18O7) and a symbol (CR) which is a brief from Columbia Resin. This detector is widely used in applications of nuclear track detectors (SSNTDs) Due to its high sensitivity [12].The detector used in a small plastic piece ($1cm \times 1cm$) is sensitive to the alpha particles released by radon and its filaments affixed to the bottom of a small plastic case (7 cm in length and 4.8 cm in diameter) as shown in Fig.1

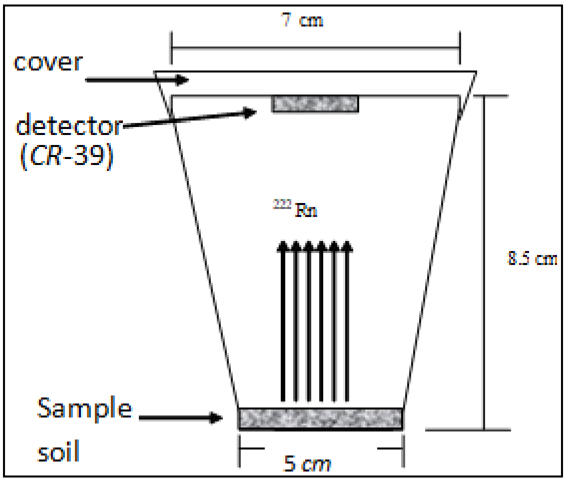

Figure 1: Schematic diagram of the sealed-cup technique

Soil samples were collected in January 2017 from the study areas, which included nine areas inside the refinery and two samples from areas outside the refinery Deep (3-10 cm).After collecting the soil samples, weight (12 g) is placed in sealed plastic containers and left for (50 days) to obtain the radiative equilibrium state.After the exposure time, we raisethe detector and then perform the chemical scaling process. The aim is to show the nuclear effects and show because the charged particles (alpha particles) produce excitation as they pass through these materials as they track narrow paths of radiation damage. These are atomic defects, And in the form of subtle effects called latent tracks and can be seen areas damaged by the light microscope after treatment with a chemical that digs and show areas of damage formed [13].For the chemical scavenging technology, we use NaOH solution and standard (6.25 N). The straw solution is placed in a water bath for heating up to 70 ° C for 6 hours. Then put the detector CR-39 inside the solution of skimming as the solution of skimming to attack areas affected by the detector and melt to leave the soluble materials in the house containing the solution straw and after the time of skimming we take the reagents to be washed with distilled water and then dried. At this stage, the effects are detected by selecting the appropriate magnification of 40X and then counting the effects of the area unit using a special lens divided into several squares and calculating the average number of effects taken for each sample. The area of the square is calculated by placing a special gradient on a glass slide in front of and Calculate the length of the large or small square, then calculate the area, and divide the Nave of the model X by the calculated area (A) to obtain the intensity of the effects [14]. As shown in figure (2).

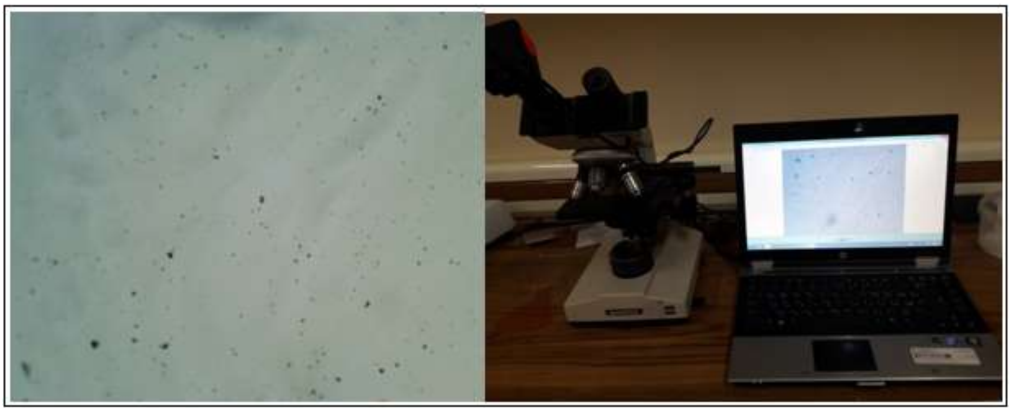

Figure 2: The track's image in the field view and the track counting

The CR-39 detector is calibrated by the standard source of Ra-226 radium, which emits Rn-222 radon at CRn-222 = 21.075 Bq / m3 for one hour of measurement. The effect of the detector for 24 hours is then estimated by taking (For the same source, Ra-226), from which the calibration factor F can be estimated from the following equation[15]:

F $(\boldsymbol{cm/Bq})$ = ρ intensity of effects / C_{Rn} concentration of radon

Radon concentration is determined in the air space of the compartment confined between the sample surface and the detector surface in units Bq/m^{3}using equation[16]:

$$C_{Rn} = \frac{\rho}{TK} \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where C_{Rn} refers to the concentration of radon in the aerospace, ρ the intensity of the effects. T exposure time (day).K Equilibrium Factor is equal to 0.4 [16].

The EEC, which represents the Equivalent Concentration value is measured in Bq/m^{3}can be found from the following relationship [17]:

$$EEC = C_{Rn} * K \quad (2)$$

The annual effective dose D (mSv / y) can be found from the relationship [18]:

$$D = C_{Rn} * K * H * T * D_f \quad \ldots\ldots\ldots \quad (3)$$

Where C_{Rn} represents the concentration of Radon concentration in unit (Bq/m^3)
K is the equilibrium factor = 0.4 (equilibrium factor)
H is the occupancy factor = 0.8
T represents the number of hours in the year = 8760h/y
D_f is the dose conversion factor =9.0 × 10^{-6} (mSv/Bq.m^{-3}.H)

Radon daughters are expressed in working levels (WL)unit, which is given by [16]:

$$WL = K * C_{Rn} * 3700 \quad (4)$$

Calculation of the concentration of radon units Working Level Month (WLM) and is given by Eq 4[17].

$$WLM = K * t * C_{Rn} 170 * 3700 \quad (5)$$

The cancer risk factor (ECR) is calculated by equation

$$ECR = WLM * 0.85 * 0.8 * 10^{-2} \quad (6)$$

We calculated Exceed Lung Cancer per Million person per year

$ELC = ECR * 10^{-2}$

3. Results and Discussion

In this study, radon concentrations were determined at different sites in Doura refinery. Table (2) shows the resulting concentrations of radon in these areas. The concentration of radon concentration in these areas shows that the highest concentration was 338.86Bq/m^3 in S5 (Assembling barrels of Ferferal (fat)). The lowest concentration was 237.76 Bq/m^3in S8(Storage of chemicals). The average value for all sites was 280.24 Bq/m^3.

The annual effective dose was then calculated from the radon concentration values as shown in Figure 3 .we note it the maximum value was 8.54mSv/y in S5 and the minimum value was 5.99 (mSv/y)in S8 . The overall average value of D(mSv/y) for 222Rn was6.49mSv/y.

With regard to radon exposure limits, the International Commission on Radiological Protection (ICRP) has identified the exposure level of the population 200 Bq/$m^3$and the annual effective dose is 0.2 mSv/y.

Table 3 shows radon concentrations and annual effective dose values in areas outside the refinery, we note that the average concentration of radon was 154.69 Bq/$m^3$and the average annual effective dose was 3.90 (mSv/y) as shown in Figure 4. It is observed that the concentration of radon in the soil outside the refinery is less than the concentration of radon in the refinery soil,but the average annual effective dose was higher than the international limit allowed.

Table 1: Name of sample

Sample	Name of area	Sample	Name of area
S1	Laboratory Gas Analyzes	S7	Cabs for barrels
S2	Casinos tanks	S8	Storage of chemicals
S3	API depot(1)	S9	API depot(1)
S	Industrial Water Treatment Unit	S10	Abu Tayara Street
S5	Assembling barrels of Ferfera”l (fat)	S11	ALshortaa District
S6	Chemical storage containers		

Table 2: Shows the radon concentrations and the intensity of the effects of different soil samples within several locations within the refinery

sample	Track average	density	C(Bq/m^3)	EEC(Bq/m^3)	wl	wlm	d(mSv/y)	ECR	ELC
S1	116.8	64.88	321.78	128.71	0.034	1.79	8.11	0.0121	12177.49
S2	95.4	53	262.83	105.13	0.028	1.46	6.63	0.0099	9946.34
S3	112.3	62.38	309.39	123.75	0.033	1.72	7.80	0.0117	11708.32
S4	86.7	48.16	238.86	95.54	0.025	1.32	6.02	0.0090	9039.28
S5	123	68.33	338.86	135.54	0.036	1.88	8.54	0.0128	12823.89
S6	93.4	51.88	257.32	102.92	0.027	1.43	6.49	0.0097	9737.82
S7	100.3	55.72	276.33	110.53	0.029	1.53	6.97	0.0104	10457.21
S8	86.3	47.94	237.76	95.10	0.025	1.32	5.99	0.0089	8997.58
S9	101.3	56.27	279.08	111.63	0.030	1.55	7.04	0.0105	10561.47
Average	101.72	56.51	280.24	112.09	0.030	1.55	7.07	0.0106	10605.49

Table 3: Shows the radon concentrations and the intensity of the effects of different soil samples outside the refinery

Sample	Track average	Density	C (Bq/m^3)	EEC (Bq/m^3)	wl	wlm	D (mSv/y)	ECR	ELC
S10	67.8	37.66	186.79	74.716	0.020	1.03	4.71	0.007	7068.78
S11	44.5	24.72	122.59	49.03	0.013	0.68	3.09	0.004	4639.54
Average	56.15	31.19	154.69	61.87	0.016	0.86	3.90	0.005	5854.16

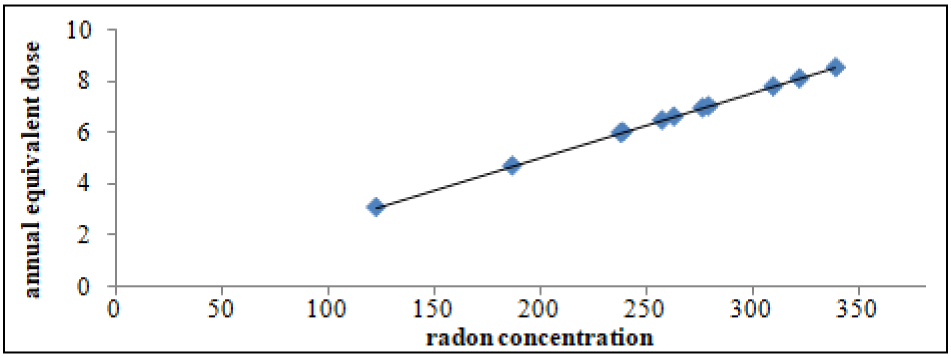

Figure 3: The linear relationship between radon concentration and the annual equivalent dose

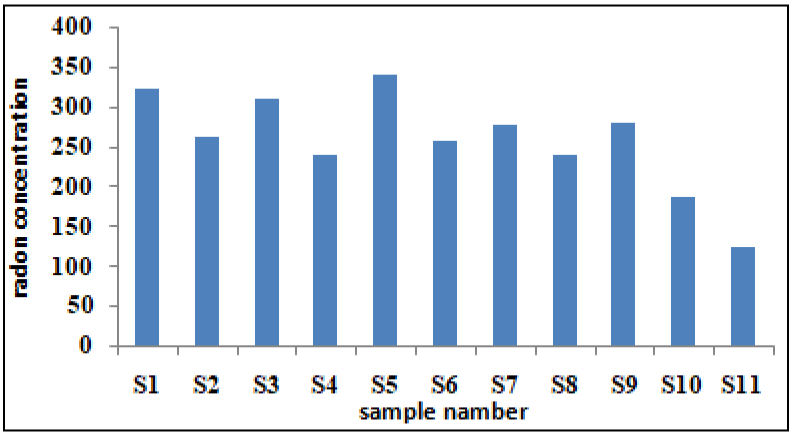

Figure 4: Concentration of radon for multiple areas inside and outside the refinery

4. Conclusions

That the results of this study show that the values obtained for the radon concentrations are higher than the levels allowed by the International Commission on Radiological Protection, which gives an indication of the presence of danger or radioactive contamination of radon in the soil.

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