International Journal of Latest Trends in Engineering and Technology
Vol.(8)Issue(4), pp.045-052
DOI: http://dx.doi.org/10.21172/1.84.06
e-ISSN:2278-621X

MEASURING THE CONCENTRATION OF RADON GAS IN THE OPERATION UNITE OF THE DOURA REFINERY

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Abstract : The concentration of radon indoor and outdoor have been measured by RAD -7 dives , where radon concentrations in operational units of the Doura refinery in the indoor range from 6.21± 30 Bq /m^3 to 12.4± 33 Bq/m^3 with an average value of 5.31±18 Bq/m^3. In open spaces ranging from 6.21±30 Bq/m^3 to (N D) with an average value of 0.44± 2.1 Bq/m^3. The result shows that the average radon levels are acceptable. Also, the estimation of annual effective dose (AED) of ^{222}Rn concentration, with the average indoor air (0.1) and outdoor air (0.007), and calculation Working Level values and Working Level Month of ^{222}Rn concentrations, show that all results are within acceptable limits.

Key words (Rad-7 / ED / WL / WLM)

I. INTRODUCTION

Radon is a naturally occurring radioactive, odorless, colorless gas that is continuously released by natural sources, such as geological formations in soil and construction materials. Radon and its daughters are formed during the radioactive decays of uranium and thorium, in the earth's crust, to lead, of which the latter is the stable product of the decay processes. The various half-lives of the radio nuclides are very important in determining the relative contributions of the decay series to bronchial dose .The half-life of ^{222}Rn is 3.8. It has four short-lived decay products: ^{218}Po (3.05 min), ^{214}Pb (26.8 min), ^{214}Bi (19.9 min), and ^{214}Po (164 µs). Both polonium isotopes are alpha-emitters. The relatively short half-life of ^{220}Rn (55.6 s) means that it does not have much time to travel from its production site to the immediate environment of human beings. The relatively long half-life of one of its decay products, ^{212}Pb (10.6 h), allows this isotope time to deposit on surfaces or migrate away from its source before producing the important alpha - emitter ^{212}Bi (60.6 min). The relative concentrations of the various radionuclides in the decay series are also strongly affected by dynamic processes, including the attachment of the decay products to aerosol particles and their subsequent deposition

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on room surfaces or the ground as well as air movement in general. The fraction of radon progeny in an ultrafine mode (0.5 - 2 nm), not attached to ambient aerosol particles, is known as the unattached fraction [1].

The inhalation of radon ^{222}Rn and its radioactive daughters, even for people exposed to low radon levels that may be found in residential buildings [2], increases the chance of developing lung cancer [3]. When inhaled, radon particles carrying daughters enter and stick onto the bronchial air passages, irradiating and damaging the surrounding cells. Based on national and worldwide investigations, several agencies have concluded that radon is a known cancer causing agent in humans and is the second most common cause of lung, skin, and leukemia cancers after smoking [4]. Radon enters the body system during inhalation, which results in an increase in the exposure dose that can result in the development of lung cancer. ^{222}Rn and its progeny in air are the most important contributors to human exposure from all natural radiation sources [5].

A. Dose Estimation

From the measured indoor and outdoor radon concentrations, annual effective doses have been calculated using equation [6].

$$E = C \times F \times H \times T \times D \qquad (1)$$

where C is the ^{222}Rn concentration (Bq/m^3), F is equilibrium factor (0.4), H is the occupancy factor (0.8 was estimated for this work), T is hours in a year (8760 h/y) and D is the dose conversion factor (9.0×10^{-6} mSv / Bq /m^3 h).

B. Calculation the (EEC) in Bq/m^3 and exposure (E) to ^{222}Rn concentrations in (WL and WLM) in operational units of the Doura refinery.

The equilibrium equivalent ^{222}Rn concentration (EEC) is calculated by using equation.

$$F = \frac{EEC}{CRn} \qquad (2)$$

Exposure to ^{222}Rn concentrations, in terms of working level (WL) and working level month (WLM), in operational units of the Doura refinery also have been calculated using equations respectively [6].

$$WL = EEC \times (0.27/\ 1000) \qquad (3)$$

$$WLM = WL \times (8760/\ 170) \qquad (4)$$

II. EXPERIMENTAL WORK

In the interior of the measurement instrument RAD-7 from Durridge Company we find a hemisphere with a silicon solid-state detector. A representation of the measurement chamber with the detector is shown in Figures 1 and 2 [7]. Through the filter the sample air is sucked in by the pump and reaches the detector chamber. There a high voltage of 2000 to 2500 V between the detector and the hemisphere accelerates the positively ionized particles towards the detector. If a radon nucleus decays in the chamber into a positively ionized ^{218}Po this particle will be accelerated towards the detector. On the surface of the detector the short lived ^{218}Po decays and the **(α)** particle with a characteristic energy is emitted to the detector. The detector produces a signal with (50) per cent probability. This signal is intensified electronically and transformed into a digital signal. The microprocessor stores the energy level of the signal and produces the spectrum.

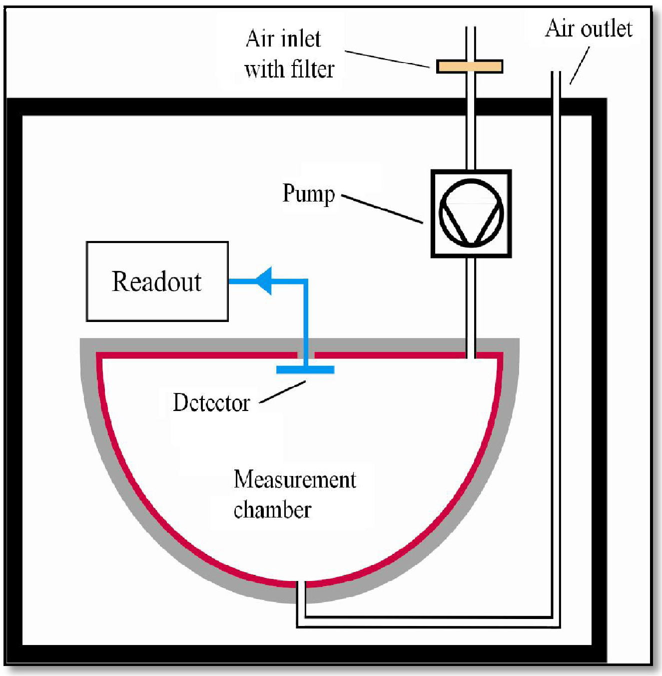


Figure 1. A diagram showing the measurement chamber of the RAD -7.

Figure 2. RAD - 7 electronic radon detectors

III. RESULTS AND DISCUSSION

The concentration of radon indoor and outdoor by RAD-7 detector has been measured, where radon concentrations in operational units of the Doura refinery in the indoor range from 6.21± 30 Bq / m^3 to 12.4± 33Bq / m^3 with an average value of 5.31 ± 18 Bq/m^3. Outdoor, concentrations of Radon gas range from 6.21± 30 Bq/m^3 to (N D) with an average value of 0.44± 2.1 Bq/m^3 as indicated in Table1.

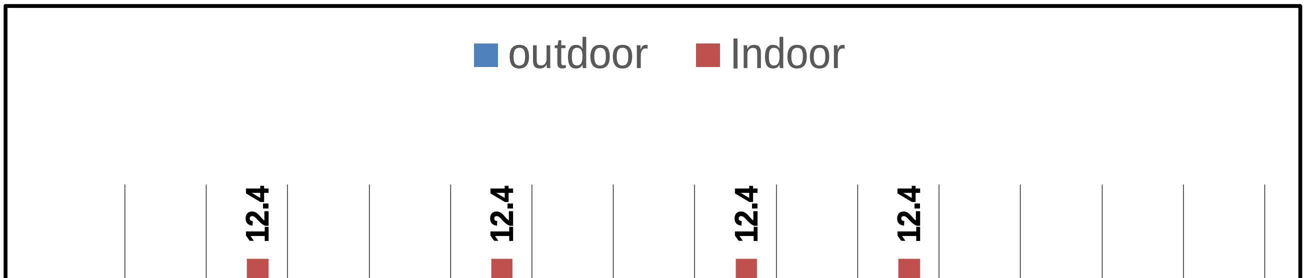
The minimum value of indoor air has been observed in the unit of (Ro), as there is good ventilation at the site being alongside Tigress River, whereas the maximum value of indoor air has been observed in department of stores, as this department is located on the ground floor, with a large area, where there is no enough ventilation.

It is also noted that the minimum value of the outdoor air has been observed in the unit of (Ro), as there is good ventilation at the site being alongside Tigress River, whereas the maximum value of the outdoor air has been observed in Improving Gasoline Unit (2) because it is located between the Improving Gasoline Unit (1) and the administration building, which affects the ventilation.

	Name of Departments	**Radon concentrations (Bq/m^3)**

No.	and Units	Indoor	outdoor
A1	Refining unit 1	6.21± 30	N D
A2	Refining unit 2	12.4± 33	N D
A3	Refining unit 3	N D	N D
A4	improving gasoline Unit 1	N D	N D
A5	improving gasoline Unit 2	12.4± 33.9	6.21± 30
A6	RO Unit	N D	N D
A7	Department of Energy (crypt water pumps)	6.21± 30	N D
A8	Department stores	12.4± 33	N D
A9	Oil Department 3	N D	N D
A10	Oil Department 2	12.4± 33	N D
A11	Oil Department 1	N D	N D
A12	Water Treatment Department	N D	N D
A13	Laboratory Heavy Water Treatment	6.21± 30	N D
A14	Department pumping and Storage	6.21± 30	N D
Average		**5.31 ± 18**	**0.44± 2.1**

Table-1 Radon concentrations in operational units of the Doura refinery.



The Radon Concentrations (Bq/m^3)

Samples	EEC	WL	WLM

Locations

Figure 3. Summary of radon concentration value in **Bq/m³** in operational units of the Doura refinery.

A. Calculation of equilibrium equivalent concentration, working Level and working level month of ^{222}Rn concentrations in operational units of the Doura refinery.

The equilibrium equivalent ^{222}Rn concentration (EEC).In addition, exposure to ^{222}Rn concentrations, in terms of working level (WL) and working level month (WLM), in operational units of the Doura refinery .

The calculated results for equilibrium equivalent ^{222}Rn concentration and ^{222}Rn exposures in terms of WL and WLM for indoor air and outdoor air in operational units of the Doura refinery were within allowable limits is as indicated in Table 2 [8]. Figure 1 and 2 ^{222}Rn exposure in WL and WLM in operational units of the Doura refinery .

	indoor	outdoor	indoor	outdoor	indoor	outdoor
A1	3.105	0	8.3×10^{-4}	0	4.3×10^{-2}	0
A2	6.2	0	1.6×10^{-3}	0	8.6×10^{-2}	0
A3	0	0	0	0	0	0
A4	0	0	0	0	0	0
A5	6.2	3.105	1.6×10^{-3}	8.3×10^{-4}	8.6×10^{-2}	4.3×10^{-2}
A6	0	0	0	0	0	0
A7	3.105	0	8.3×10^{-4}	0	4.3×10^{-2}	0
A8	6.2	0	1.6×10^{-3}	0	8.6×10^{-2}	0
A9	0	0	0	0	0	0
A10	6.2	0	1.6×10^{-3}	0	8.6×10^{-2}	0
A11	0	0	0	0	0	0
A12	0	0	0	0	0	0
A13	3.105	0	8.3×10^{-4}	0	4.3×10^{-2}	0
A14	3.105	0	8.3×10^{-4}	0	4.3×10^{-2}	0
Average			**7.1×10^{-4}**	**5.9×10^{-5}**	**3.6×10^{-2}**	**3×10^{-3}**

Table-2 the calculated values of (EEC) in Bq/m^3, and exposure (E) to ^{222}Rn concentrations in (WL and WLM) in operational units of the Doura refinery.

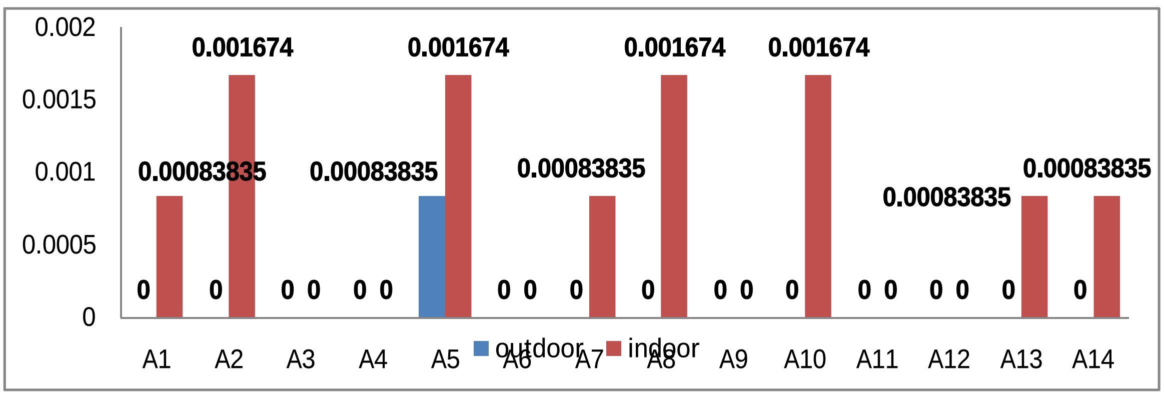


Figure 4. ^{222}Rn exposure in WL in operational units of the Doura refinery

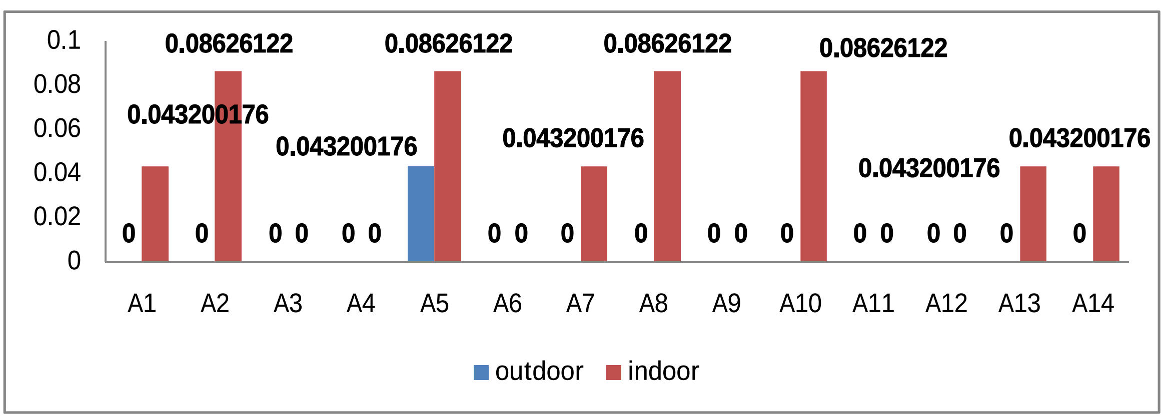


Figure 5. ^{222}Rn exposure in WLM in operational units of the Doura refinery

B. The Estimation of Annual Effective Dose of ^{222}Rn Concentrations in operational units of the Doura refinery.

The estimation of annual effective dose (AED) of ^{222}Rn concentration in operational units of the Doura refinery were measured as indicated in Tables: 3 where all results were within the allowable limits.

Tables -3 the annual effective dose and of ^{222}Rn Concentrations in operational units of the Doura refinery.

NO	C (Bq/m^3) indoor	annual effective doses mSv/y	C (Bq/m^3) outdoor	annual effective doses mSv/y
A1	6.21± 30	0.1	N D	0
A2	12.4± 33	0.3	N D	0
A3	N D	0	N D	0
A4	N D	0	N D	0
A5	12.4± 33.9	0.3	6.21± 30	0.1
A6	N D	0	N D	0
A7	6.21± 30	0.1	N D	0
A8	12.4± 33	0.3	N D	0
A9	N D	0	N D	0
A10	12.4± 33	0.1	N D	0
A11	N D	0	N D	0
A12	N D	0	N D	0
A13	6.21± 30	0.1	N D	0
A14	6.21± 30	0.1	N D	0
Average	**5.31 ± 18**	**0.1**	**0.44± 2.1**	**0.007**

NO	C (Bq/m^3) indoor	annual effective doses mSv/y	C (Bq/m^3) outdoor	annual effective doses mSv/y
A1	6.21± 30	0.1	N D	0
A2	12.4± 33	0.3	N D	0
A3	N D	0	N D	0
A4	N D	0	N D	0
A5	12.4± 33.9	0.3	6.21± 30	0.1
A6	N D	0	N D	0
A7	6.21± 30	0.1	N D	0
A8	12.4± 33	0.3	N D	0
A9	N D	0	N D	0
A10	12.4± 33	0.1	N D	0
A11	N D	0	N D	0
A12	N D	0	N D	0
A13	6.21± 30	0.1	N D	0
A14	6.21± 30	0.1	N D	0
Average	**5.31 ± 18**	**0.1**	**0.44± 2.1**	**0.007**

IV. CONCLUSION

The most important isotope of radon from a health standpoint ^{222}Rn decay products , especially ^{218}Po and ^{214}Po, it can have a clear negative impact on lung tissue, leading to lung cancer in many cases. Entry of radon gas In housing usually occurs through cracks, joints, pipe fittings in the walls, and sealants loose or dam on Windows, and so on. Based on RAD -7 portable device, it was measured ^{222}Rn in operational units of the Doura refinery in the indoor range from 6.21± 30 Bq /m^3 to 12.4± 33Bq/m^3 with an average value of 5.31±18 Bq/m^3. In open spaces ranging from 6.21±30 Bq/m^3 to (N D) with an average value of 0.44± 2.1 Bq/m^3, the results were below the action level recommended by WHO of 100 Bq/m^3. The annual effective dose in air indoor (0.3) mSv/y, and outdoor (0.1) mSv/y. These results are much less than acceptable results. On the basis of the current results, it can be concluded that the radon levels in indoor and outdoor within acceptable values in the operational units of the Doura refinery.

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