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Measurement Of Rn^{222} Concentrations In The Air Of Peshraw & Darbandikhan Tunnels Located In Sulaimani Governorate Of Kurdistan Region-Iraq.

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ABSTRACT: The purpose of this study was to measure the radon concentration in the air inside Darbandikhan and Peshraw tunnels located at Sulaimani governorate. The concentration of Rn^{222} have been determined using CR-39 Solid–State Nuclear Track Detector Technique. It was found that the range of radon concentration inside Darbandikhan tunnel was (305.8 - 391.34) Bq/m^3 , and that of Peshraw tunnel was (2042.9 - 4277.89) Bq/m^3. A concentration of several thousand Bq/m^3 was observed at the inner most area of the Peshraw tunnel towards southern geographic which indicates that the radon concentration in the tunnel is basically governed by diffusion and mixing of radon gas with air.

Keywords: Radon-222 , SSNTD , activity , CR-39

I. INTRODUCTION

Radon is a naturally occurring noble gas (z=86) and all of its isotopes are radioactive. Because of its chemical inertness it does not bond to the surface of material, in marked contrast to its heavy metal daughters. From a health physics point of view, the main hazard is the alpha radiation dose to the lungs. This dose is mainly due to direct radiation from inhaled dust particles on which the radon daughter nuclide ions have become attached [1], therefore it's necessary to study this type of gas in the tunnels and in closed positions. Due to its long half life time (3.82d) relative to other isotopes, radon (Rn^{222}) (a gas member in the uranium decay series) is considered to be the most significant isotope of radon problem in the environmental studies. the SSNTD (Solid State Nuclear Track Detector) technique, make a popular and well-established method of measurement in a large number of fields of radioactivity or nuclear interactions. The basis of this technique lies when heavy charged particle traverse a dielectric medium, they are able to leave long – lived trails of damage that may be observed either by transmission electron microscopy or under an ordinary optical microscope after etching the medium using NaOH for 6 hrs at 70 C^o temperature [2, 3].

The plastic SSNTD detectors are most widely used because they are more sensitive than crystal and glass. The type of CR-39 polymer (a polly allydiglycol) Carbonate can record all charged nucleons (protons) [2]. Cellulose nitrate and acetates can record alpha particles .The lexan ploy carbonate is one of the earliest plastic SSNTD to be used which can record the nuclei of charge (z>6). The shape and type of damage position on the film plastic detector depend on the mass, energy, the charge of the incident particle and on the type of solid state detector [2, 4]. The damage volumes of these positions depend upon the above factors adding on the type and concentration with temperature and time of chemical etching [3].

The interactions of radiation with these types of polymers occur due to degradation or molecular cross-Linking with each other, these effects causing to change the polymer properties. Therefore, when radiation falls (incident) on these polymers, it causes excitation and ionization, as well as causing to cut the bond and producing damage traces on the polymer at the normal condition [5]. These traces have the capability to interacting with alkaline solution like (NaOH) comparing with the undamaged regions. Due to this interaction these regions have more energy than the others, then the chemical solution penetrate easily the radiate position causing bracing with high depth and diameter which can observe by optical microscope [3].

In Sulaimani governorate, till now there is no base line data concerning the radon concentration measurements in closed areas, especially for the Darbanikhan tunnel (located East-Southern of Sulaimani city, constructed before 50 years ago) and for the Peshraw tunnel (at Northern of Sulaimani city which was constructed before 4 years ago) where some ambiguities on their quality and health characteristics have been mentioned. Therefore, this work has been adopted to assess the radon levels inside both of the tunnels in comparison to the standard international values.

II. EXPERIMENTAL TECHNIQUE & CALCULATION

In this work, Solid-State Nuclear Track Detector techniques has been employed by using CR-39 detectors which were fixed inside the steel chambers in a form of 1X1.5 cm plastic detector pieces, (Fig. 1). The designed dosimeters have been suspended on the walls of tunnels at different positions along the tunnel. After 60 days of exposure the suspended dosimeters were collected.

Fig. (1): The designed dosimeter.

To calculate radon concentration using a dosimeter chamber, it's necessary to determine the diffusion constant (K) characteristic for the system using the relation [6]:

$\rho = K\, C_a\, T$ …………..(1)

Where P- Track density Tr\cm^2

K- Diffusion constant

C_a - Rn concentration in air space inside the steel chamber (Bq\cm^3)

T- Exposure time (60 days)

Then K can be calculated for the specified dimensions of the steel chamber [7]:

$K = 1/4\ (r)[2\cos\theta_t - r\backslash R_\alpha\ ]$ ……………….(2)

Where r - chamber radius for the diffusion volume (3.25 cm)

- θ_t - Threshold angle for the CR-39 detector (35^o) ,[7]
- R_α - Range of α- particle in air from Rn

R_α can be calculated from this relation [8]:

$R = (0.005\ E_\alpha + 0.285)\ E_\alpha^{3/2}$ …………………..(3)

= 4.019cm (for alpha energy of 5.489 MeV)

Substituting these values in eq. (2), the diffusion constant is found to equal 0.058244 Tr.cm^{-2}.hr^{-1}/ Bq.m^{-3} For the present dosimeter

III. RESULTS AND DISCUSSIONS

Tables 1 & 2 presents the track density of α–particles on the CR-39 detectors within the dosimeters and the measured Rn-concentrations for both tunnels:

Table 1 (Darbandikhan tunnel)

Position (m) at side of Sulaimany	ρ(Tr/cm²)	Ca (Bq/m³)
0	905.4	259.0824806
60	1153.8	330.1627635
120	1068.9	305.8684156
180	1134.9	324.7544811
240	1344.3	384.6748163
300	1316.7	376.7770071
360	1222.3	349.7642103
420	1120	320.4908088

480	1079.3	308.8444017
540	1320.4	377.8357714
600	1367.6	391.3421697
660	1251.3	358.0626331
720	1210	346.2445345
780	1173.6	335.8285832
840	1350.6	386.4775771

Table 2 (Peshraw tunnel)

(Peshraw Tunnel) at side of Sulaimany position (m)	P(Tr/cm²)	Ca(Bq/m³)
0	11334.1	3243.281139
100	9353.4	2676.498867
200	10516.6	3009.351464
300	14949.7	4277.894146
400	11805.7	3378.230662
500	10584.5	3028.781219
600	11719.2	3353.47847
700	14462.4	4138.452029
800	13450.9	3849.008768
900	12253.7	3506.426985
1000	14564.5	4167.6682
1100	10998.9	3147.362818
1200	7762.5	2221.258842
1300	8294.8	2373.577822
1400	8897.5	2546.041939
1500	8205.8	2348.110249
1600	9088.7	2600.754298
1700	9931.8	2842.009477
1800	8182.2	2341.35705
1900	8756	2505.551359
2000	7139.3	2042.928599
2100	7860	2249.158712
2200	5378	1538.928187

From Table 1, the radon concentration at the gates of Darbandikhan tunnel were 259.08 Bq/m^3 and 386.48 Bq/m^3, and along the tunnel length (800m) were ranges between (305.8 – 391.3) Bq/m^3. From Table 2, the radon concentration at the gates of Peshraw tunnel were 3243.28 Bq/m^3 and 1538.93 Bq/m^3, and along the tunnel length (2200m) were ranges between (2042.93 – 4277.89) Bq/m^3. In both tables, a higher radon concentration have been recorded at one of the tunnel gates (386.48 Bq/m^3 for Darbandikhan and 3243.28 Bq/m^3 for Peshraw tunnel). This may be referred to the regional wind currents that are lower in compare to the other side which exposes to higher air currents. The distribution of radon concentration within Darbandikhan and Peshraw tunnels are shown in Figures 1 and 2, respectively.

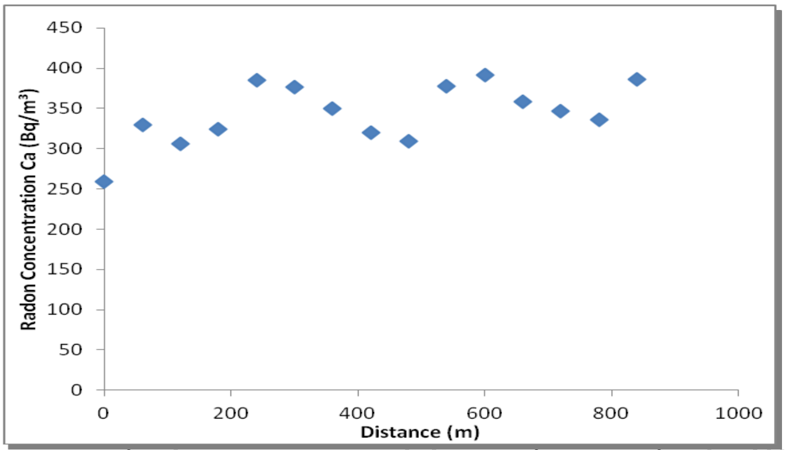

Figure (2): Variation of Radon Concentration with distances from gate of Darbandikhan tunnel.

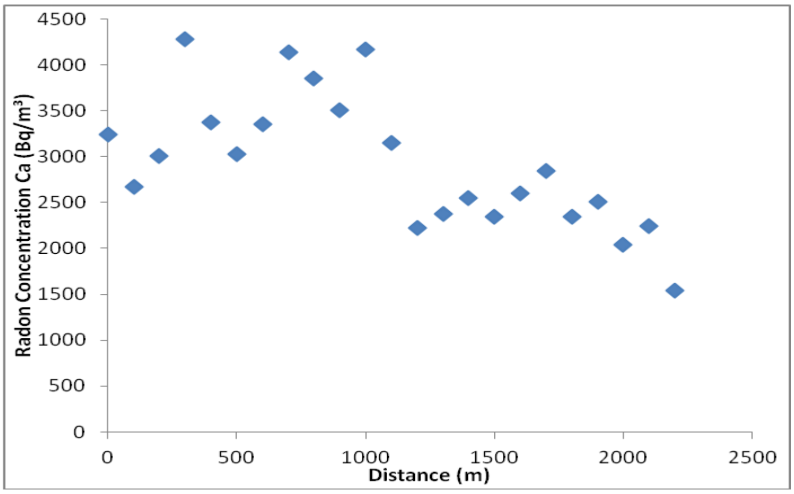

Figure (3): Variation of Radon Concentration with distances from gate of Peshraw tunnel.

In both figures, and in the same manner, two peaks have been appeared at approximately same distances from the tunnel ends. This phenomenon reveals that the radon concentration decreases with distance from inside to outside of the tunnel. At the center of the tunnel, the radon emanation from the rocks was directed toward the lower concentration regions at the ends, but the air directed inside of the tunnel from the gates retards this translation and causing accumulation at the indicated regions. Furthermore, these observations lead to the conclusion that the variation of the radon concentration in the tunnel air is mainly caused by a convection current due to stack effect induced by the temperature difference between the tunnel air and the outside air [9].

In general, the ventilation in both of the tunnels not exists. So the radon concentration levels were higher than those recorded for a tunnel in Korea 95.1 Bq/ m^3 [10], while they are still lower than those recorded for a tunnel in Japan 6500 Bq/m^3 [9]. Nevertheless, it is necessary for the tunnels to have good ventilation for decreasing high radon concentrations and the other none desired gas concentrations.

From the results, it was clear that the radon concentration in Peshraw tunnel was higher than that of Darbandikhan tunnel which is attributed mainly to the length excess of Peshraw tunnel over that of Darbandikhan tunnel (about three times) that causes more trapping of radon gas to higher concentrations.

On the other hand, the operations of making tunnels involve drilling of the mountains with different geological formations and then covering the walls inside the tunnels with a large nugget of cement. In this work, the geology of the area is predominantly characterized by metamorphic rocks, these kinds of rocks usually rich in uranium minerals which is also be a radon source [11].

IV. CONCLUSION

In this work, the concentration of Rn was found very high in the Peshraw tunnel comparing to Darbandikhan tunnel due to the length difference. Both of the tunnels left without ventilation which causes higher radon concentration comparing to that of Korea but they are smaller than that of Japan due to geology and environmental formations.

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