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Study of Soil Contamination with Radioactive Radon Gas in Industrial Environments

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Annotation: Aims of research to measure the concentrations of radioactive radon gas in brick production factories in area of Shomali- Babylon, 13 soil samples were selected and collected from inside the work sites, the CR-39 nuclear trace detector It has been approved for measurement and analysis, lowest of concentration was 604.55 ± 7.11 Bq/m³, while highest of concentration was 1663.64 ± 15.89 Bq/m³. The overall average of the study samples was 1300.35 Bq/m³, Exceeded the safe level of 600 Bq/m³. These results are considered indicators of health impact to workers and the local population, necessitating adherence to occupational safety standards by workers and the need to conduct ongoing biological and environmental studies.

Keywords: Radionuclides, CR-39 Detector, Radon Gas, Brick Factoreis.

Introduction

Radon gas is a naturally occurring radioactive element that is colorless and odorless, Due to its radioactive nature, it requires specialized measuring devices and materials to detect it and determine its concentrations accurately [1]. Radon gas is one of the main sources of ionising radiation affecting human health, as it contributes 55% of the background radiation dose to the environment, with concentrations varying depending on the nature of the region and the annual season [2]. Rn^{222} is considered the most dangerous, as its half-life allows it to exist in water, indoor and outdoor air, making it a direct environmental contaminant [3]. The different characteristics of the soil directly affect the concentrations of radon gas, as (moisture, soil texture, organic matter, and pH level) play a major role in the process of radon transport and emission [4], and the radium content, grain size, type of mineralisation, and emission factor all contribute to determining the extent of its spread and emission from the soil surface [5]. Exposure to high concentrations of radon gas for long periods of time poses potential health risks to humans. It causes respiratory diseases and lung cancer, according to the International Agency for Research on Cancer (IARC) [6]. Although it is a naturally occurring element, it cannot be completely eliminated, and adopting preventive strategies and measures to reduce its emission is essential to minimise its environmental and health risks and ensure safe levels of exposure.

Materials and Methods

Samples of this study were collected from brick factories of brick in Al-Shomali - Babylon, with 13 soil samples, the coordinates and names of the factories were documented as in Table 1,

Table 1: Location coordinates of the study samples

Code of Sample	Factoreis of Brick	Lat (N)	Long (E)
Sample 01	Al-aietimad	32.4075	45.0775
Sample 02	Al-haziz	32.4034	45.0805
Sample 03	Al-raafidayn	32.4046	45.0827
Sample 04	Al-masara	32.4030	45.0834
Sample 05	Al-salam	32.4006	45.0844
Sample 06	Al-rawasi	32.3997	45.0866
Sample 07	Guobran	32.3972	45.0877
Sample 08	Al-munaa	32.3972	45.0904
Sample 09	Aaatim turkiun	32.3946	45.0914
Sample 10	Abu turki	32.4013	45.0986
Sample 11	Al-yaqin	32.3989	45.1021
Sample 12	Al-bahja	32.3997	45.1088
Sample 13	Wisam Turki	32.4013	45.1130

after the collection process of samples, were air-dried under sunlight, and ground and sieved to obtain a homogeneous soil powder before the measurement process. The samples were placed in sealed plastic containers with a CR-39 nuclear trace detector on top at a specified distance from the soil surface as in Figure 1, and the samples were left for 60 days in a completely opaque place. After this period, the reagents placed in the reaction chamber were chemically skimmed using NaOH solution, and then the alpha paths emitted in the reagents were calculated using a light microscope, and then the mathematical calculation [7].

Mathematical calculations

The radioactivity of radon in the study samples was determined by the following mathematical methods [8, 9,10]

1. Calculate the radon concentration in the air inside the vessel according to the equation

$C(Bq/m^3) = \rho/(K \times t)$ …..(1)

(ρ) represents the track density on the detector, (t) represents the exposure time, and (K) refers to the calibration factor.

2. Calibration factor (K):

$K = 0.25\ r^2 \cos\theta c - r / r\alpha$ ……(2)

(r) is the inner radius of the reaction chamber (r=0.75), (θc) is the critical angle of the CR-39 detector (θc= 40°) , (rα) is the alpha particles in air (4.15 cm), The calibration factor has been considered 0.022 Tr /cm³ per Bq/m³.

3. Radon concentration in the sample:

$C\ (Bq/m^3) = (C \times \lambda \times h \times t) / l$ ……(3)

(λ) represents the decay constant of radon-222, which is 0.1814 days¹. (h) refers to the distance between the surface of the soil sample and the detector used, (t) represents the irradiation time of 60 days, and (l) refers to the thickness of the soil sample layer in the reaction chamber.

4. concentration of radon in the soil sample was determined by the equation:

$C\ (Bq/kg) = (C \times l \times A) / M$ ……(4)

In this equation, (A) represents the surface area of the soil sample, while (M) refers to the total mass of the soil used for analysis and measurement.

5. Determine the concentration of radon radioactivity in the soil sample according to the equation:

$A\ (Bq) = C \times V$ ……(5)

(V) represents the volume of the soil sample in cubic metres, and (C) represents the previously calculated radon concentration.

Results and Discussion

The data showed that the radon gas concentrations varied among the samples, sample (S1) recorded the lowest value at 604.55 ± 7.11 Bq/m³, while sample (S8) recorded the highest concentration of 1663.64 ± 15.89 Bq/m³.Table 2 show concentrations of radon gas in the soil samples.

Table 2: Concentrations of Rn ^{222} in soil samples

Code of Sample	Rn ^{222} Bq/m³
1S	604.55±7.11
2S	1416.67±12.45
3S	1078.79±11.31
4S	1250.00±12.36
5S	1143.94±10.90
S6	1490.91±15.40
7S	1342.42±13.83
8S	1663.64±15.89
9S	1310.61±14.29
10S	1210.61±11.98
11S	1496.97±15.93
12S	1400.00±13.94
13S	1495.45±14.94

between these values, the rest of the study samples varied with moderate to high levels, while the average radon concentrations in the samples reached 1300.35 Bq/m³, which in itself is much higher than the permissible limit of 600Bq/m³ [6]. The results indicate that the radon contamination in the study samples was not limited to only one sample, but included all samples. Even the samples with lower concentrations still exceeded the internationally recommended limit, as well as indicating that the contamination in all the studied sites and not in a specific location. The variation in radon concentrations in the samples shows that the nature of the soil or different industrial conditions affect the accumulation of the gas directly. These levels represent a real risk to workers. Inhaling radon at levels above the permissible limit leads to an increased accumulation of radiation doses within the respiratory tract, and with continued exposure, the risk of lung cancer and respiratory diseases increases. Figure 2 shows radon concentrations in soil samples.

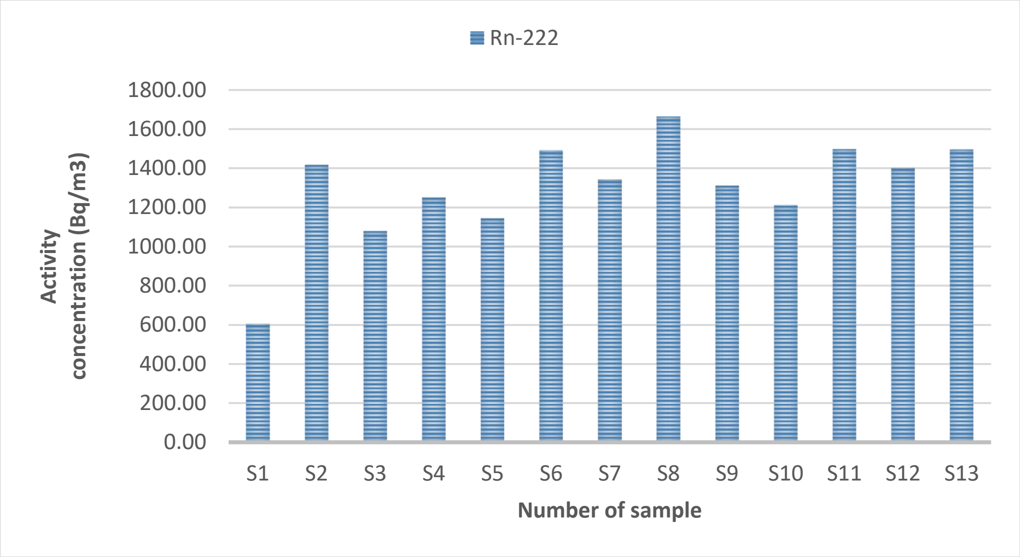

Figure 3: Concentrations Rn ^{222} in soil samples

Conclusions

The results obtained in this research show that the radon gas concentrations in the soil of all brick factories exceeded the health-acceptable level, without recording any value within the safe levels. These high concentrations of radon gas pose an environmental and health risk. The persistence of these high levels means an increase in the risk of serious respiratory diseases, especially lung cancer and respiratory diseases, so a set of preventive measures must be adopted such as improving ventilation and personal occupational protection in the working environment in brick factories to prevent and minimise the risks, and the importance of conducting regular biological and environmental tests to monitor radon radioactive contamination.

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