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Radiation dose assessment due to 222Rn of some soil samples in Dywaniya city, Iraq

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***Abstract*—Radioactivity level of Ra^{226} in soil samples was determined using NaI (Tl) detector. Soil samples were collected from Dywaniya city (Sniya, Sadeer, Bdeer, Shanafeya, city center, and Summer). Results showed the presence of natural radionuclide Ra^{226} in some soil samples. In order to evaluate the radiological hazard of the natural radioactivity, the mean resulted dose has been calculated.**

***Keywords*—Radon, Natural radioactivity, Gamma spectrometry, NaI (Tl), Environmental radioactivity**

I. Introduction

Radon Rn^{222} is a radioactive, noble gas (half life 3.825 d) and has been discovered, together with its two isotopes (Rn^{220}, 55.6 s and Rn^{219}, 3.965 s) in 1900. Rn^{222} is a decay of radon in air where it diffunds from soil, is due to the uranium contents of soils (1-7). Radon presents a certain health hazard, due to its short lived progenies (Po^{218}, Pb^{214}, Bi^{214}, Po^{214}) that may deposit within the lung (8-10). The main objective of this study was to identify and determine natural radionuclide concentrations in soil samples collected from Dywaniya city. Useful for establishing base line data on the gamma background radiation levels in different areas of Dywaniya, Iraq for assessment of radiation exposures to the population. Radium, radon concentrations, and the resulted dose from the inhalation of radon gas were determined for all the analyzed soil samples.

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II. Materials and Methods

Samples of soil were collected from Six regions in Dywaniya city in Iraq (Fig.1), and these regions are: Sniya, Sadeer, Bdeer, Shanafeya, City center, and Summer. The samples were dried and pulverized. Each sample was then weighed and sealed in Marinelli beaker. The gamma spectroscopy system was used for the quantitative and qualitative determination of radionuclides. Gamma spectroscopic measurement was performed using a NaI (Tl) detector (Leybold Cassy Lab, Pocket-CASSY 524058) with diameter 1.76" and thickness 1.56". The system has efficiency of about 50% and a energy resolution (FWHM) of about 7.5% at energy at 662 keV (^{137}Cs) which is considered adequate to distinguish the gamma-ray energies of interest in this study. The detector is surrounded by a lead shielding in 5 cm thickness. A constant counting time for calibration sources (^{60}Co, ^{137}Cs, ^{22}Na, ^{241}Am, and ^{226}Ra) from the International Atomic Energy Agency, for the background spectrum, and for measuring soil of 1 h was adopted. Instrument calibration was done at multiple energies from 25 keV to 2500 keV.

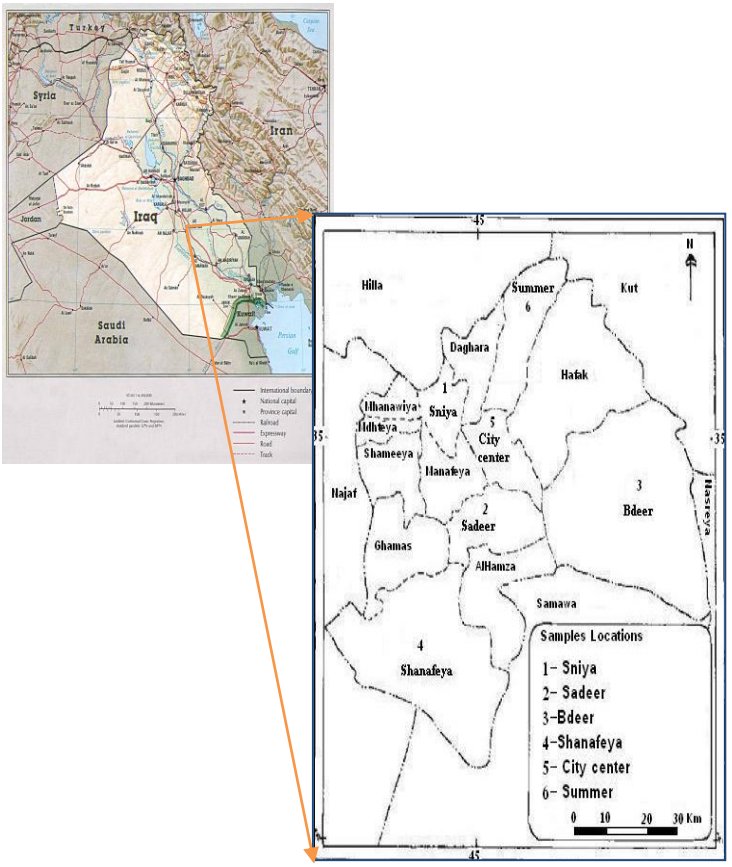

Fig. 1. Iraq and administrative Dywaniya maps with sampling sites

A. *Calculation of Specific Radioactivity*

The activity level for Ra^{226} in the measured samples was computed using the following equation (11-15)

$$A = \frac{C}{\varepsilon P W} (Bq\ kg^{-1}) \qquad (1)$$

where A is the activity level of a radionuclide expressed in Bq kg^{-1}, C is the net counting rate of sample subtracted from background (count per second), ε is the counting efficiency of the used detector, P is the absolute transition probability of

gamma decay (16-18, 12-15), and W is the dried sample weight expressed in kg.

The radon concentration in the soil was calculated according to [19]:

$$C_{Soil} = F_r x \rho x C_{Ra} \quad (2)$$

where:
C_{Ra}= radium concentration (Bq kg^{-1}), ρ = density of soil (1600 kg), F_r= emission rate (0.1), and C_{Soil} = radon concentration in the soil (Bq m^{-3})

The radon concentration in the air was calculated according to the equation:

$$C_{Air} = C_{Soil}\sqrt{\frac{D_{Soil}}{D_{Air}}} \quad (3)$$

where:
C_{Air}= concentration of radon in the air (Bq m^{-3}), D_{Soil}= proliferation constant in the soil ($0.5x10^{-4}$ m^2 sec^{-1}), D_{Air}= steady proliferation in the air (5 m^2 sec^{-1})

The resulting dose by radon gas inhalation was calculated according to by (20):

$$H_p = IC_p x I_P x D_{CE} \quad (4)$$

where:
IC_P=concentration of radon in the air, I_p=amount of consumption of the air outside the home (1600 m^3 y^{-1}), D_{CE} = Conversion factor of radon gas in units ($1.3x10^{-9}$ S Bq^{-1}).

III. Results and Discussion

The radium concentrations in the soil samples are showed in Table I. The concentration of Ra^{226} in Sniya sample was higher than Shanafeya sample. Therefore, the concentrations found in samples can be ordered as Sniya> Summer Sadeer > city center> Shanafeya (Table I). The radon concentration has calculated in the air and soil (Table II). The resulted dose has calculated from the inhalation of radon gas (Table III).

TABLE I. RADIUM CONCENTRATION IN SOIL SAMPLES

Location	*Concentration (Bq kg^{-1})*
Sniya	550.80±20.38
Sadeer	254.20±30.47
Bdeer	ND
Shanafeya	42.37±20.19
City center	84.74±33.28
Summer	338.90±37.05

ND=not detected

TABLE II. CONCENTRATION OF RADON IN SOIL SAMPLES AND AIR

Location	*Radon in soil $x10^3$ Bq m^{-3}*	*Radon in air Bq m^{-3}*
Sniya	99.00	313.06
Sadeer	45.72	144.57
Bdeer	ND	ND
Shanafeya	7.62	24.09
City center	15.25	48.22
Summer	61.00	192.89

TABLE III. CAUSED DOSE BY THE RADON GAS INHALATION

Location	*Dose (mS y^{-1})*
Sniya	0.65
Sadeer	0.30
Bdeer	ND
Shanafeya	0.05
City center	0.10
Summer	0.40

IV. Conclusions

Mean resulted dose of 0.3 mS y^{-1} was obtained for the air. These results is lower than the International Commission on Radiological Protection (ICRP) maximum permitted limit and therefore, have no radiological health burden on the environmental and the populace. In this study, the result (0.65 mS y^{-1}) in Sniya was lower than the recommended limit of radiation exposure dose (1 mS y^{-1}) (IAEA, 1996).

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