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Radioactivity of Some Soils in the University of Tikrit, Iraq, college of Education for Girls using Solid-State Nuclear Track Detector type CR-39

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Abstract

In this research radon concentrations in soil samples of some sites of the College of Education for Women, University of Tikrit, were measured using CR-39 nuclear impact detector. Soil samples were prepared according to classical protocols whereby they were irradiated for a period of 65 days in propagation chambers chemically treated and subjected to optical microscopy to calculate nuclear effects. The results show differences in the concentrations of radon gas in the samples collected from different sites ranging between a lowest value $161.600\ x\ 10^3 Bq.m^{-3}$in the location of the department of English and a highest value of $441.533\ x\ 10^3 Bq.m^{-3}$ in the location of the cafeteria of College compared to the radiation background of $161.158\ x\ 10^3 Bq.m^{-3}$due to the geological factors that depend on the type and specifications of the soil, the amount of gases emitted from the soil, the amount of the emergence of radon from the granules of the soil and its spread through the pores of the soil to the outside.

Keywords: Soil, Radon, Detecter.

النشاط الإشعاعي لبعض أنواع التربة في جامعة تكريت العراق كلية التربية للبنات باستخدام كاشف الأثر النووي CR-35

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الخلاصة

تم في هذا البحث دراسة النشاط الإشعاعي لبعض مواقع كلية التربية للبنات جامعة تكريت وذلك بإيجاد تركيز غاز الرادون Rn^{222} لعينات من التربة لبعض مواقع الكلية .حيث تم قياس تركيز غاز الرادون Rn^{222} لتلك المواقع باستخدام كاشف الأثر النووي **CR-39** اذ تم تحضير العينات قيد الدراسة بطريقة علمية وفقا لعدة مصادر في هذا المجال وبعد مدة استمرت(65يوم) تم جمع العينات ومعاملتها كيميائيا وفق مصادر علميه ,ثم تم حساب الآثار النووية باستخدام مجهر ضوئي وأظهرت الدراسة اختلاف نسب تركيز غاز الرادون في العينات قيد الدراسة حيث تراوحت بين اقل قيمة $161.600 \times 10^3 \mathrm{Bq.m^{-3}}$ وذلك في موقع قسم اللغة الانكليزية واعلى قيمة $441.533 \times 10^3 \mathrm{Bq.m^{-3}}$ وذلك في موقع كافتريا الكلية مقارنة مع الخلفية الإشعاعية مقدارها $161.158 \times 10^3 \mathrm{Bq.m^{-3}}$ ويعود السبب في ذلك إلى العوامل الجيولوجية التي تتوقف على نوع ومواصفات التربة وعلى كمية الغاز المنبعثة من التربة وعلى كمية انبثاق غاز الرادون من حبيبات مادة التربة وعلى انتشاره عبر مسامات التربة إلى الوسط الخارجي

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Introduction

Radiation activity is a phenomenon that occurs naturally in a number of active radioactive materials that emit certain types of radiation automatically within a specified period [1]. The highest levels of radiation are produced from sources of ionizing radiation and nuclear explosions that cause environmental pollution and the effects are then reflected on humans . For example the Hiroshima and Nagasaki bombs in 1945 **,** where this incidence was the beginning of environmental pollution followed by many other incidences that led to a significant impacts in the contamination of large areas of the planet , In addition, other sources of pollution included the processes resulting from the use of radioactive sources in fields which was caused by man (industrial, agricultural and medical ,military ect.).This is the reason behind the a need to study the effects of radiation how to detect it how to identify the extent of pollution in the environment , and how to treat that pollution and how it is processed [2]. Thus, several studies were conducted and several techniques emerged to calculate the specific activity of substances in soil, water and other substances and the effect of those radioactive substances in living organisms. An important technique used to detect these radioactive materials is the Solid-State Nuclear Track Detectors SSNTD'S, This technique is an important technique in determining the concentration of radioactive materials because of their abundance and accuracy and no need for complex systems. In my study SSNTD'S are used to calculate the specific activity of radon in soil samples of the sites of the Faculty of Education for Women University of Tikrit [3]. Radon is found in nature as a low-concentration gas that spreads in most places and underground water [4]. Radon concentration levels in the air vary from a location to other [5].

Radon has two main isotopes(actinon and thoron)**,** radon Rn^{222}**,** one of the radio nuclides made up of the uranium U^{238} series, one of its members that spreads on the earth's surface or in its atmosphere **.** The concentration of radon irradiated Rn^{222} in the air or building materials is very important for human safety and protection measurements The radon in the air and soil is a widely used technique to indicate the presence of uranium U^{238}. The simplest way to measure the concentration is the use of solid-state detectors for nuclear impact (-SSNNTD'S) for a long time to record the pathways of damage caused by alpha particles emitted from radon decomposition and cores [6]. Aman Allah and Obaid [2011] measured specific activity of radon Rn^{222} for soil samples collected from locations in Salah al-Din province, Iraq, using CR-39 nuclear impact detectors, and reported that the recorded activity range was (17.6-27.1Bq/m^3) [7]. In 2013, Mohammed also measured the specific activity of radon for soil samples from-"Al-Jadiriya-Baghdad-Iraq". and reported radon concentrations range (of 57.47-85.49Bq/m^3) [8]. The CR-39 nuclear detector used in our current study with hydrocarbon composition ($C_{12}H_{18}O_7$) has Hydrogen ratio (6.6%), Due to the high detection and sensitivity of the detector, it was used in many applications, such as its use in recording the effects of protons and alpha particles [9].

The current study aims to measure irradiated radon concentrations in soil models for some sites of the College of Education for Women University of Tikrit and to compare them with the radiological background using a nuclear impact detector (CR-39).

(Department Quran Science Model 1, Department Quran Science Model 2, Department Life Science Model 1, Department Life Science Model 2, Department of Psychology, Department Chemistry Model 1, Department Chemistry Model 2, College Mosque, History section, Department English Language, Department Arabic Language Model 1, Department Arabic Language Model 2, College Medicine, In Front Of Cafeteria, Right of Deanship, Left of the Deanship, Behind the Deanship, Mathematics department, In Front of College, Behind the College, Radiological background)

Mechanism of occurrence of effects on the surface of the detector .The mechanism of occurrence of impact depends on the surface of the detector on generating particles charged in solid insulating materials where a number of relics are generated as they pass through those materials. This can be observed using an electron microscope or optical microscope after being treated with a chemical that shows the areas of damage formed. The type and shape of the damage depends on the mass**,** energy and charge of the fallen particles and the type of solid detector material[10]. The theory of Ion Explosion spike is the theory that can explain the mechanism or how the effect arises . polymers are made up of molecules bound together called monomers, which are linked to each other in most plastics by a covalent bond dominated by hydrogen-carbon atoms (hydrogen-carbon)This is easy to break when exposed to radiation, where the production of small (polymera chains) with effective ends called free radicals which have the ability to interact with each other or with other atoms [11].

The main effect of radiation on polymers is their degradation or the intertwining of their molecules with each other (cross-linking) ,and these two effects represent the major changes in polymer properties .
The fall of radiation on these polymers leads to the irritation and ionization of these particles, and breaking cut the bonds between them , This damage in the polymer material does not disappear under normal circumstances , and this effect is called the latent track [12].
Areas damaged by the ionizing radiation have greater ability to interact with alkaline solutions, such as sodium hydroxide $\boldsymbol{NaOH}$ compared to non-damaged areas , as the damaged areas possess more energy than the non-damaged areas. Therefore, the chemical solution penetrates the irradiated areas rapidly, causing an effect that increases its depth and expands its diameter while increasing the time of skimming . The latent track can be seen after being shown under a light
microscope [13] .

Materials and Methods:

Diffusion Coefficient:-

The measurement of the radon concentration is based on the diffusion coefficient **k** , which can be determined for the propagation chamber used in this study by the following relationship [14]

$$\rho = KCT \quad \ldots\ldots (1)$$

where:
ρ:Intensity of impact Track/cm^2
K: Diffusion constant
C:Radon concentration in aerospace $Bq.cm^{-3}$
T:Irradiation time in second of Equation [10]

$$D = \frac{\rho}{T} = K.C \quad \ldots\ldots (2)$$

where:
D: the density rate of the effects $Tr.Cm^{-2}.h^{-1}$

It is also possible to find the propagation constant as depending on the geometric dimensions of the propagation chamber from the relationship [11]

$$K = 1/4r(2Cos\theta_c - \frac{r}{R_\alpha}) \quad \ldots\ldots (3)$$

where:
r:Tube radius = 2.75cm
θ_c:The chamber angle of the detector CR-39 = 35°
R_α:The extent of the alpha particles in the air emitted by Rn^{222}=4.15cm
So will became [11]

$$R_\alpha = (0.005E_\alpha + 0.285)E_\alpha{}^{3/2} \quad \ldots\ldots (4)$$

where:
E_α:Alpha particle energy MeV

The K value depends on the geometric dimensions of the propagation chamber therefore, when calculating the k from equation 3**,**the value of the diffusion constant in length units is equal to
$K = 0.6164cm$

Calculation of radon concentrations in aerospace and sample:

The concentration of radon in the air space of the compartment confined between the sample surface of the detector in the propagation chamber can be calculated in $Bq.cm^{-3}$ units of the relationship[13]:

$$D_{Rn^{222}} = \frac{C}{4}\mathrm{r}\left(2\mathrm{Cos}\theta_c - \frac{r}{R_\alpha}\right) \ldots\ldots (5)$$

Calculation of radon concentration in samples: -

The concentration of radon in samples can be obtained from the following relationship[13]

$$C_s = \frac{\lambda_{Rn} C_\alpha h t}{L} \ldots\ldots (6)$$

where:
C_s:Radon concentration within samples$Bq.m^{-3}$.
C_α:Radon concentration in aerospace $Bq.m^{-3}$.

λ_{Rn}:Constant decay radon 0.1814day^{-1}[15].
h:High air space = 7 cm.
L:The sample thickness is approx. = 1.5 cm.
t:Time of irradiation in days , its value 65 days.

Nuclear detectors were used in this study to detect the radiation activity of soil samples of some sites of the College of Education for Women - University of Tikrit**,** Reagents were placed in closed spread chambers (Sealer Diffusion Chamber) in a cylindrical shape .The are agents placed against the sample to measure its concentration of radon gas . The chamber was closed tightly to prevent leakage or exchange air with surrounding air. After the radon was released into the chamber, decomposes and releases the alpha particles and after the state of balance between it and its offspring was achieved, the detector was allowed to be exposed to the sample as the moves it to experimental work rate of the radon offspring on the walls of the chamber [16].

Soil samples were taken from some sites of the College of Education for women - University of Tikrit as in the table

Sample code	Study site
S1	Department Quran Science Model 1
S2	Department Quran Science Model 2
S3	Department Life Science Model 1
S4	Department Life Science Model 2
S5	Department of Psychology
S6	Department Chemistry Model 1
S7	Department Chemistry Model 2
S8	College Mosque
S9	History section
S10	Department English Language
S11	Department Arabic Language Model 1
S12	Department Arabic Language Model 2
S13	College Medicine
S14	In Front Of Cafeteria
S15	Behind cafeteria
S16	, Right of Deanship
S17	Left of the Deanship
S18	Behind the Deanship
S19	Mathematics department
S20	In Front of College
S21	Behind the College
S22	Radiological background

Then the samples were grinded to obtain homogeneous and smooth powder samples to ensure consistent distribution of the radioactive material in each sample, so that they are ready for examination and analysis . Detector CR-39 was used as a technique for detecting radioactive contamination. The long-term measurement technique was used to obtain traces of alpha particles emitted from radon from the samples, The detector was a CR-39 , with a thickness of $500\ \mu m$ and a dimension of $(1 \times 2)cm^2$.The samples used in front of the reagent were of 10 g of each sample, and the amount to be studied was determined by a sensitive balance 0.5×10^{-2}. The samples were placed in cylindrical irradiation chambers, called propagation chambers diameter [5.5cm]. The chambers were closed tightly by a rubber plug while keeping the distance between the surface of the sample and the surface of the rubber to 7 cm Samples were then left for a period of 25 days to obtain a state of ideal balance (**Secular Equilibrium**) of up to 98% between radon and its offspring of radon isotopes [15] .

To prevent the occurrence of leakage of radon gas out of the spread rooms, the rubber was removed and replaced quickly with another rubber containing a piece of detector CR-39 It was tightly closed again with an adhesive tape value with keeping the dimension between the detector and the sample face before lifting the rubber. The reagents inside irradiation chambers remained for a period of 65

days after which all the detectors were removed and the samples were prepared to the process of chemical etching using $NaOH$ a solution with purity up to 98% - This latest operation will show the intensity of the effects left by the radon on the detector. The temperature associated with this process was 70 ° C and the concentration of the solution was 2.5 M consisted of dissolving 25 g of $NaOH$ its molecular weight 40 in 100 m.L distilled water [17] .
After seven and a half hours of the process of etching with sodium hydroxide solution the samples were removed from the solution , washed thoroughly with distilled water, dried, and finally prepared to be examined under the optical microscope (Figure-1) where detection and calculation of the number of effects arising on the face of the detector was achieved.
After calculating the number of traces left by the interaction between the alpha particles (emitted from radon) and the detector surface facing the samples we calculated the radiation background of the CR-39 detector, In the same period that the detectors used were exposed to samples, one of the detectors was placed in a sealed and sample-free tube. The purpose of this was to compute the radiation background of the CR-39 detector .Figure-2 shows the image of the effects of one of model.

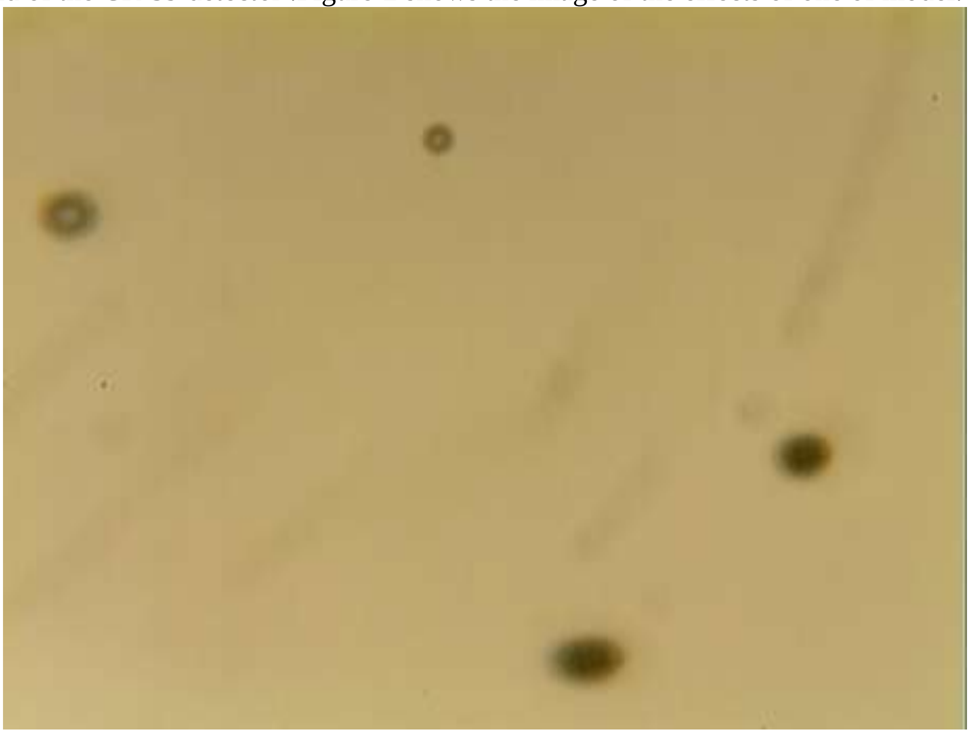

Figure 1-show the effects of one of the soil samples under study

Results and discussion

Table-1 shows the samples taken from some sites of the University of Tikrit and offset by the amounts of the intensity of the effects they are offset by the intensity of the effects of alpha particles and the concentration of radon in the aerospace and in the samples.

Table 1-The locations of surface soil samples with intensity of impact, and concentration of radon in aerospace in caption of table

Sample code	Study site	Intensity of impact $Track/m^2x10^6$	Concentration of radon in aerospace $Bq.m^{-3}x10^1$	Concentration of radon in sample $Bq.m^{-3}x10^{-3}$
S1	Quran Science Model 1	129.444	373.931	205.754
S2	Quran Science Model 2	240.555	694.903	382.368
S3	Life Science Model 1	111.111	320.972	176.613
S4	Life Science Model 2	104.722	302.515	166.458
S5	Psychology	259.166	748.666	411.951

S6	Chemistry Model 1	166.666	481.456	264.919
S7	Chemistry Model 2	148.055	427.694	235.337
S8	Mosque College	129.444	373.931	205.754
S9	History section	175.833	507.937	279.491
S10	English Language	101.666	293.687	161.600
S11	Arabic Language Model 1	129.444	373.934	205.754
S12	Arabic Language Model 2	194.444	561.700	309.073
S13	College Medicine	157.222	454.175	249.908
S14	In Front Of Cafeteria	277.777	802.428	441.533
S15	Behind cafeteria	157.222	454.175	249.908
S16	Right of Deanship	203.611	588.181	323.644
S17	Left of the Deanship	101.666	293.687	161.600
S18	Behind the Deanship	222.222	641.949	353.227
S19	Mathematics department	111.011	320.972	176.613
S20	In Front of College	222.222	641.949	353.227
S21	Behind the College	231.388	668.422	367.797
S22	Radiological background	101.388	292.847	161.158

Table-1 shows that the concentration of radon and the intensity of recorded effects, which ranged in value compared to the radiation background between$(101.666 - 277.777) x\ 10^6\ tr/m^2$ In the site of the College cafeteria and the department English language site radon in the antenna space of the irradiation chamber ranged from the lowest value $(267.209x\ 10^1\ Bq.m^{-3})$ in the Life Science Model 1 site and the highest value of $(802.428\ x\ 10^1 Bq.m^{-3})$ in the site cafeteria . Radon concentration in the sample under study was $(161.600\ x\ 10^{-3} Bq.m^{-3})$in the English language site and the highest value was $(441.533x\ 10^{-3}\ Bq.m^{-3})$ in the site of the College cafeteria ,in other locations, these values ranged between these two values, thus showing a difference in radon gas ratios to four times the radiation background of $(161.158\ x\ 10^3 Bq.m^{-3})$ These percentages are within the normal limit, but the difference in radon concentrations in the samples is due to different geological nature which depends on the type and specification of the soil , the amount of gas emitted from the soil , and the amount of radon gas emmitted from the granules of the soil and spread through the pores of the soil to the outside.

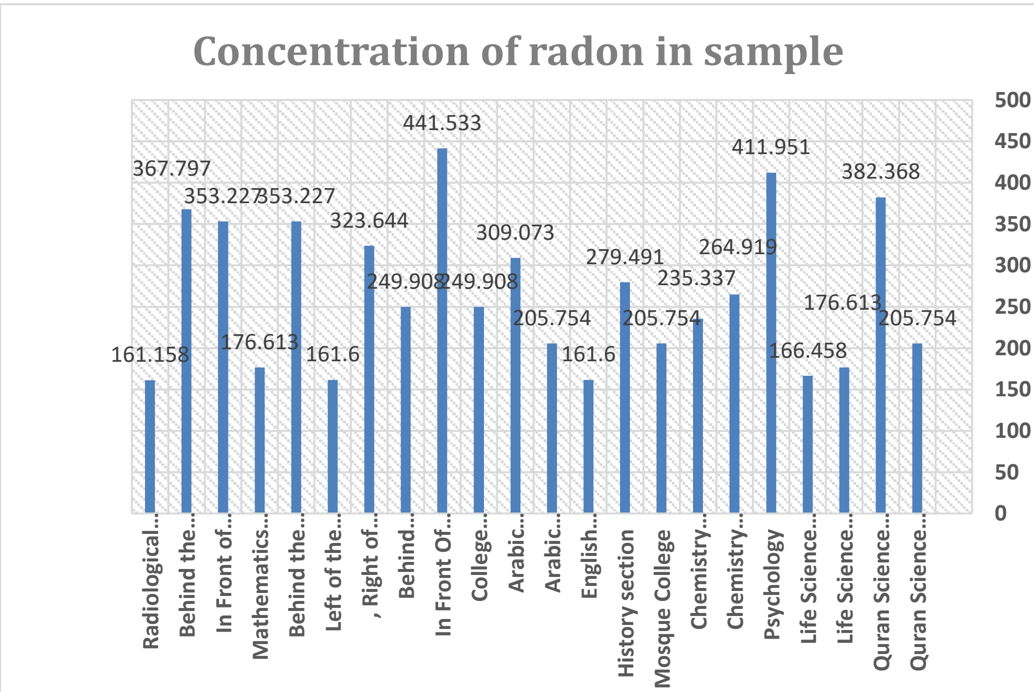

Figure 2-shows the radon as a function of these sites at the College of Education for Women - University of Tikrit for radiological background

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