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Determination Of Radioactivity Levels From Some Egyptian Building Materials

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ABSTRACT

Our world is radioactive and has been, since it was created. Over 60 radionuclides (radioactive elements) can be found in nature. Radon is naturally occurring radioactive gas, that is produced by the radioactive decay of radium. Breathing high concentration of radon can cause lung cancer. A set of experiments were carried out using CR-39 as solid state nuclear track detectors with the optimum etching conditions, 6.25N Na OH at 70°C for 8 hours. The radon-222 activity in this survey was found to be in the range of 0.303 kBq/m^3 to 5.04 KBq/m^3 for different building materials in Egypt.

Key words : *Building material , Radon , solid state nuclear track detector*

INTRODUCTION

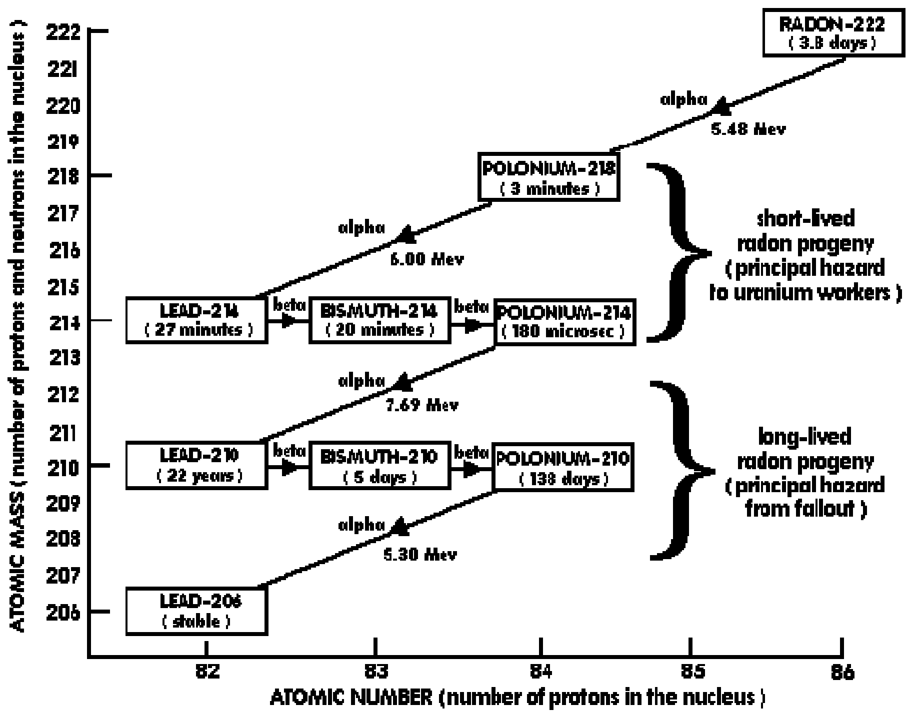
To estimate the uranium and thorium concentration in natural samples, solid state nuclear track detector (SSNTDs) can be used. The most popular and sensitive type of SSNTDs is CR-39. The interaction of passing α-particles through atoms of this detector produces latent tracks, which are related to total energy loss rates, primary ionization and restricted energy loss**.** These tracks can be revealed using chemical etching process at suitable etching conditions. The chemical attack along the damaged and undamaged regions has two different velocities; VT, VB, the track etch rate and the bulk etch rate respectively. The track etch rate, VT, will be along the trajectory of the track itself. [G.E.khalil *et al.,* 2004]

Soils, rocks and building materials are porous. When a radium atom is located close to the surface radon escapes to pore space and ultimately through interlinked pore spaces to the surface and into the surrounding air. There is, however, a major difference in half-life between radon-220 and radon-222. Radon-220 has a half -life of only 54.5 s , whereas that of radon–222 is 3.82 days. Radon–220 released to the pore space at an appreciable depth within the material will decay before reaching the surface and will not contribute to the airborne concentration of radon-220. Radon-222, on the other hand, can migrate considerable distances before decaying [Kenawy *et al.,* 2001].

The release of radon-220 to the environment is therefore a surface-layer effect, whereas the release of radon-222 is a bulk effect [Misdag et *al.,* 2000].In most environments the activity concentration of radon –222 exceeds that of radon–220, but the decay products of the latter do contribute to human exposure.[*Kenawy et al., 1991].*

The chart below lists all of the decay products of radon gas (radon-222) in their order of appearance. They are called the "radon progeny" (formerly "radon daughters"). Each radioactive element on the list gives off either alpha radiation or beta radiation and sometimes gamma radiation too – there by transforming itself into the next element on the list. Lead-206, the last element on the list, is not radioactive. It does not decay, and therefore has no half-life as shown in figure1. The decay of radon gas produces reductive particles [Font *et al.,* 1999**].**

Once inhaled, these particles may be retained in the lungs. Emit 'bursts' of energy, damaging lung tissue and potentially resulting in lung cancer. Consequently, the main hazard of indoor radon comes from the short-lived radon decay products (RDP) [Kenawy *et al.,* 1991].



When radon and its decay are in equilibrium in a system, the α- activity is the sum of the three equal activities of ^{222}Rn , ^{228}Po, and ^{214}Po. The nucleus of ^{222}Rn , ^{218}Po and ^{214}Po radiate α-particles possessing 5.49, 6.00 and 7.69 Mev , respectively . The range of these particle in the atmosphere are estimated to be 4.0, 4.6, 6.0, respectively .

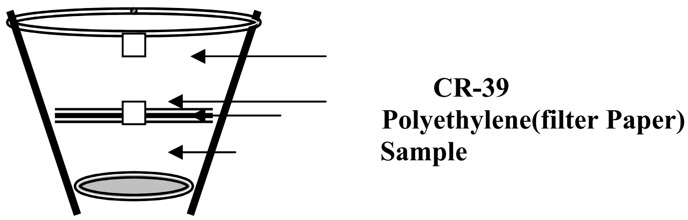
MATERIAL AND METHODS

As this study is concerned with potential exposure to radiation from materials used within a building . The materials analyzed were those primarily used in the construction of internal walls, floors and ceilings.

The most common types of building materials include concrete , red brick , sand , white brick , natural gypsum , natural building stone , tiles , ceramics , granite .. etc .[E.M.Lec, *et al.*, 2004]

In the present work we have used solid state nuclear track detectors(SSNTD) in cup technique [ABU.Garad *et al.,* 1984]

The detector used is CR-39 which is amorphous polly allay Diglycol carbonate of 500 μm thickness. It has been shown that this detector is very sensitive to alpha particle radiation with energy up to 40 Mev [Fleisher *et al.,* 1975]



Figure(2): Shows a schematic illustration of a passive radon dosimeter for long term radon measurements. The CR-39 incubated in plastic can and the sample was covered with filter paper (Can technique)

Ten samples of each building material were kept for 30 days in sealed can with two CR-39 samples, one in the top of the can and the other one on the surface of polyethylene (filter paper).
The regions selected in Egypt were shown in the figure(3). Selected locations were Cairo, Jizah , EL-Fayuom , Bani Uosef , Al Minya , Asyut , Aswan , Qena , EL Suez, Port Said , Sinai , Red Sea , Marsa Matruh, Hurghada, Tanta, and Alexandria .

Figure(3) Illustrates the selected locations from different building materials in Egypt

One month after exposure in each can , the CR-39 detectors were retrieved, etched in 6.25 NaoH for 6 hours at 70 ^{0}C, then counted, using an optical microscope (X160)

Our laboratory specifies a background of 100 tracks /cm^2 , a calibration factor of 1.37 track cm^{-2} kBq^{-1} h^{-1} m^3 from the equation and errors shown in the result are due to the counting statistics ± (4-10)% for air.
It's in agreement with [A.F. Maged., 1997]

$A=K^{-1}\rho$

Where ρ is the number of tracks/cm^2
A - is the radon concentration
K - is constant where ***k*** is a calibration factor [**1.37 tracks cm^{-2} kBq^{-1} h^{-1} m^{-1}**]

Measurements of radon concentration in soil by CR-39 detectors.

The density of tracks counted was assumed proportional to the radon exposure. the relation for radon concentration is given by [D. Mazur. M. Janik *et al.,* 2002]

$$C = \frac{N - N_B}{KSTM}$$

where
C - radon concentration [kBq m^{-3}]
N - total No. of traks counted
NB- No. of background tracks
S - Field of view [S=13.3 x $10^{-4}cm^2$]
M - Number of counted field
K - is calibration factor = **[0.27± 0.01 track cm^{-2} per kBq h m^{-3}]**

RESULTS AND DISCUSION

The experimental work of this study was designed to measure radon concentrations for some building materials in Egypt form different locations such as Cairo, Jizah , EL-Fayuom , Bani Uosef , Al Minya , Asyut , Aswan , Qena , EL Suez , Port Said , Sinai , Red Sea , Marsa Matruh, Tanta, and Alexandria, noticing that,

1. CR-39 nuclear track detectors have been used to establish this as illustrated in methodology .
2. The errors shown in the results are due to the counting statistics between (4-10)% ±
3. The effective equivalent dose from radon-222 concentration is given by the relation HE / I Rn-222 ≈ 1.5 10^{-10} Sv per Bq. [ICRP 1981]
4. Limits for inhalation of radon daughters were estimated to fall between 3 and 10 msv, which is the range of action levels recommended by the international commission on radiological protection (ICRP) [C.A. *et al.,* 2004]
5. The concentration of radon for some building material using CR-39 detector as follows .

Measurement of Radon in different regions in Egypt

Table (1) Illustrates the location of sample and material, radon concentration (kBq/m^3)and Dose Equivalent ($mSvy^{-1}$)

Location	Material	Radon concentration (KBq/m^3)	Dose Equivalent($mSvy^{-1}$)
CR-39 at 7cm distance from cement samples			
Helwan	Helwan cement	0.761	0.986
Sinia	White cement	0.303	0.392
Asyut	Asyut cement	0.565	0.731
Agent	Fahd cement	0.555	0.719
Qena	Qena cement	3.340	4.328
CR-39 at surface of cement samples			
Helwan	Helwan cement	1.20	1.555
Sinia	Helwan cement	0.40	0.518
Asuite	Helwan cement	0.79	1.023
Agent	Fahd cement	1.59	2.060
Qena	cement Qena	3.30	4.276
CR-39 at 7cm distance from Sand Samples			
Jizah	Abo-Saliba sand	0.82	1.062
EL-Sharkia	Belbais sand	0.699	0.905
Mara-Matroh	Chelopatra sand	1.40	1.814
EL-Kaluobia	Abo-Zabal sand	1.29	1.671
Jizah	Bany-uosof sand	0.883	1.079
CR-39 at Surface of Sand Samples			
Jizah	Abo-Saliba sand	1.995	2.585
EL-Sharkia	Belbais sand	1.83	2.371
Mara-Matroh	sand Chelopatra	2.62	3.395
EL-Kaluobia	Abo-Zabal sand	2.25	2.916
Jizah	Bany-uosof sand	1.06	1.373

Table (2) Illustrates the location of sample and material, radon concentration (kBq/m^3)and Dose Equivalent ($mSvy^{-1}$)

Location	**Material**	**Radon concentration (KBq/m^3)**	**Dose Equivalent($mSvy^{-1}$)**	
CR-39 at 7cm distance from stones samples				
Jizah	Bany Uosof stone	1.67	2.164	
Marsa-Matroh	EL-Alamin at 98km stone	1.90	2.462	
EL-Fayoum	Red Brick	2.7	3.499	
Elmanya	Stone (Blocks)	1.73	2.242	
EL-Fayoum	Rayan Valley stone	0.72	0.933	
Marsa-Matroh	Cleopatra stone	2.52	3..265	
CR-39 at Surface of building stones samples				
Jizah	Bany Uosof stone	3.71	4.808	
Marsa-Matroh	EL-Alamin at 98km stone	4.32	5.44	
EL-Fayoum	Red Brick	2.95	3.823	
Elmanya	Stone (Blocks)	3.29	4.263	
EL-Fayoum	Rayan Valley stone	2.97	3.849	
Marsa-Matroh	Cleopatra stone	2.99	3.875	

Table (3) Illustrates the location of sample and material, radon concentration (kBq/m^3)and Dose Equivalent (mSvy^{-1})

Location	Material	Radon concentration (KBq/m^3)	Dose Equivalent(mSvy^{-1})	
CR-39 at 7cm distance from ceramics samples				
10th of Ramadan city	Cleopatra ceramic	1.04	1.34	
Fayuom	EL-Ahlia ceramic	2.44	3.16	
Alexandria	Lecico ceramic	2.25	2.916	
Agent	Prima ceramic	2.42	3.136	
Agent	Misr ceramic	3	3.88	
Agent	Aracimco ceramic	1.87	2.42	
CR-39 at surface of ceramics samples				
10th of Ramadan city	Cleopatra ceramic	1.59	2.06	
Fayuom	EL-Ahlia ceramic	3.03	3.926	
Alexandria	Lecico ceramic	2.8	3.628	
Agent	Prima ceramic	2.58	3.343	
Agent	Misr ceramic	1.88	2.436	
Agent	Aracimco ceramic	1.36	1.17	
CR-39 at 7cm distance from porcelain samples				
Agent	Black porcelain	1.98	2.56	
Agent	Olive color porcelain	0.90	1.16	
Agent	Pointed gray porcelain	1.3	1.68	
Agent	Gray porcelain	1.5	1.94	
CR-39 at surface of porcelain samples				
Agent	Black porcelain	2.21	2.86	
Agent	Olive color porcelain	1.01	1.308	
Agent	Pointed gray porcelain	1.88	2.43	
Agent	Gray porcelain	1.92	2.488	

Table (4) Illustrates the location of sample and material, radon concentration (kBq/m^3)and Dose Equivalent (mSvy^{-1})

Location	Material	Radon concentration (KBq/m^3)	Dose Equivalent(mSvy^{-1})
CR- 39 at the surface of painting			
Cairo	Crital	1.02	1.32
Cairo	Pakin	0.99	1.283
Port Said	Kapcy	5.04	6.53
Tanta small volume	Pakin2002	0.895	1.159
Tanta large volume	Pakin2002	0.833	1.079
Alexandria	Mido	0.406	0.526
CR-39 at 7cm distance from painting samples			
Cairo	Crital	0.9	1.16
Cairo	Pakin	0.8	1.03
Port Said	Kapcy	4.5	5.83
Tanta small volume	Pakin2002	0.7	0.90
Tanta large volume	Pakin2002	0.6	0.77
Alexandria	Mido	0.40	0.51
CR-39 at 7cm distance from clay samples			
Jizah El Saf	Clay	4.6	5.961
Fayoum Kom Oshim	Clay	1.90	2.462
Sharkia Belbais	Clay	1.34	1.736
CR39 at The surface of clay			
Jizah- ElSaf	Clay	6.33	8.203
EL-Fayoum	Clay	4.45	5.767
EL-Sharkia belbais	Clay	3.5	0.36
CR-39 at surface of marble			
Hurghada	Marble	1.29	1.67
Aswan	Marble	2.08	2.69
EL-Manya	Marble	1.94	2.514
Red Sea	Marble	3.70	4.79

CONCLUSION

In the recent years , it had been recognized that increased concentrations of radon and it's daughters, particularly when concentrated in enclosures such as houses , workplaces , mines and other important regions . So radon activity can be employed
as indicators for public protection.
The ^{238}U & ^{232}Th contents are in the building material and radon and thoron exhalation rates were measured by using CR-39 nuclear track detectors .
The building material used should be characterized by lower concentration of ^{226}Ra and ^{224}Ra to avoid health hazards. It's then possible to establish a data for all building materials exit in market using etch track technique instead of spending much money and resources to perform a large scale nationwide indoor radon measurements.
It can be concluded from the experimental results that:

1. The influence of the etchant temperature and concentration, on the bulk etching rate V_B of the solid state nuclear track detectors (CR-39) used in this work could be summarized as follows; the bulk etching rate of the CR-39 foils etched in NaOH or KOH solutions of concentrations ranging from 2N to 12N, at different temperatures are in excellent agreement with the relation $V_B = A \exp(-E_a/kT)$. It is observed that for the same molarity and etching temperature, V_B is higher in KOH than NaOH.
2. The CR-39 plastic possesses the unique ability of giving charged particle etchable tracks of lowest *dE/dx* threshold of all known SSNTDs till now.
3. One of the problems when using CR-39 as with all the plastic detectors is the variation of its track etch properties from manufacturer to manufacturer and from sheet to sheet, this fact makes necessary the measurement of the bulk etching rate every time plastic is used.
4. The optimum etching conditions for our CR-39 were 6.25N NaOH at 70 ^oC which leaves the plastic surface smooth with well defined tracks.
5. In general, the bulk etching rate increases slowly at low etchant concentrations, and then more rapidly with increasing the etchant concentration.
6. The CR-39 plastic track detector is almost a good recorder of damage due to ionizing particle interaction with matter where it is very sensitive (REL threshold of 26 $MeV.g^{-1}.cm^{-2}$) and homogeneous (gradual increase in track diameter as the depth).

7. The environmental effects on the characteristics of track registration in CR-39 were found to be distinct. It has been found that the complete annealing of alpha tracks occurs after 15 minute of annealing at 300 ^oC.

The main conclusions are given in the following
The maximum values are found in air by CR-39 for building material [Qena cement co. 4.328 msv/y, then Marsa Matroh sand 1.814 msv/y, Red brick of Fayuom 3.499 msv/y, EL Ahalia Ceramic3.16 msv/y, Porceline Prima 2.564 msv/y, Kapcy painting co 6.53 msv/y. and Marble of red sea 4.79 msv/y, Clay EL Saf 5.96 msv/y]
And the minimum value for building material [white cement 0.392 msv/y , Fahd Cement 0.719 msv/y , Belbas Sand 0.905 msv/y, stone Rayan Valley Stone 0.933 msv/y , Cleopatra 1.762 msv/y , olive Porcelin1.16 msv/y , Mido painting co. 0.526 msv/y, Belbais clay 1.736 msv/y, hurghada marble 1.671 msv/y]
the maximum value is 21.87 msv/y and minimum value is 6.38 msv/y
so we recommend the following
1- using the building material of low concentration of radon as possible
2- In Fayuom, red brick emitted higher levels of radon than that of stones, so its strongly recommended to use building stone than red brick .

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