Determination of ^{222}Rn activity in the sediments of Basrah Governorate marshes (Iraq) using Solid State Nuclear Track Detectors (SSNTDs)

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Abstract

Radon activity concentration levels were measured in the sediments of Basrah Governorate marshes, Iraq. There included Al-Qurna marsh and Al-Mediena marsh. The selected areas were chosen according to civilian population. CR-39 and LR-115 type 2 detectors in a cylindrical plastic container technique used in this investigation. Maximum activity of radon levels (18329 Bq m^{-3}) observed in Al-Hyader sediments and minimum levels (1769 Bq m^{-3}) were observed in Umelha both samples from Al-Mediena marshes. While in all sediments of Al-Qurna marsh, the activity of radon were found between (10740-1985) Bq m^{-3} which are in natural limits according to (ICRP). The anomalous values of activity of sediments in some stations were discussed .

Keywords: Radon, CR-39, LR-115 type 2, sediments, Activity (Bq m^{-3}), marshes.

الخلاصة

تم قياس مستوى فعالية تركيز الرادون في رواسب اهوار محافظة البصرة (العراق) وتتضمن اهوار القرنـه والمدينـه واختيـرت مناطق الدراسة حسب التجمعات السكانية. استخدمت تقنية الاسطوانة المغلقة للكاشفين CR-39 و LR-115 type2 فـي هـذه الدراسة. لوحظ ان القيمة العظمى الفعالة للرادون (1829 Bq m^{-3}) في منطقة الحيادر والقيمة الصغرى (1769 Bq m^{-3}) في منطقة الاميلحة وكلتا المنطقتين تقعان في هور المدينة . بينما وجدت فعالية تركيز غاز الرادون في رواسب هور القرنة تقع بـين (10740-1985) Bq m^{-3} والتي هي ضمن الحدود المسموح بها حسب (ICRP) . تم تحديد و مناقشة المناطق الشاذة في مـتن هذا البحث.

Introduction

Radon is unique natural gas and radioactive element in all of its isotopes. These two characteristics which are unusual in their combination [Virk and Singh., 1993]. Measurement of radon are importance because the radiation dose to human population due to inhalation of radon and its daughters contributes more than 50% of the total dose from natural sources [UNSCEAR,1988].The dose deriving from the presence in the air of ^{222}Rn is linked to the inhalation of its short –lived daughters, which are deposited in the respiratory organs, if deeply inhaled, emit alpha-particles in direct contact with the bronchial and pulmonary epithelium. For these reasons, the dose deriving from the exposure to ^{222}Rn in closed spaces has been placed in direct relation to the risk of lung cancer [ICRP, 1987]. Outside air typically contains very low levels of radon, however, it may build up to higher concentrations indoors when it is unable to disperse [Rasas, 2003]. Solid state nuclear track detectors (SSNTD) have been extensively used in this regard and almost all branches of science and technology [Al-Kalifa, 2005, Fleischer et al., 1975]. In the present study, we use a SSNTD technique based on determining detection efficiencies of the CR-39 and LR-115 type II solid state nuclear track detectors for measuring alpha- particles due to the radon and thoron series. The relevant ranges of the emitted α -particles in air and SSNTD utilized, were calculated by means of a TRIM program [Ziegler, 2007]. In this work we used (SSNTDs) to evaluate radon concentrations in various sediment samples are

brought from marshes of Basrah governorate, and to set a baseline data for these areas which would be of great help for radiological database of Iraq.

Method of Study

The sediments samples were collected from different locations in Basrah marshes as shown in Fig.(1). The sediment samples are taken from the bottom of each location. The number of sediment samples is 42. Each sediment sample is dried in the oven at 110 ^{o}C and milled in the grinder. Finally, all samples are sieved (riddled) in sieve with 600 μm pores. Each sample of sediment of 1cm height is placed in the bottom of the closed cylindrical plastic container as shown in the Fig.(2) [Misdaq, 1997].

Identical 1x1.5 cm of CR-39 and LR-115 type II SSNTDs have been separately placed at a distance of 9 cm above the sample for three months. Two identical films of CR-39 and same from LR-115 type II are used for each sample to get a high accuracy. This long time of irradiation is necessary to accumulate considerable number of tracks of α -particles that emitted from radon, thoron and their progenies.

After the irradiation, the exposed films were developed in an NaOH solution with chemical etching conditions 2.5 N at 60 ^{o}C for 120 minutes for LR-115 type II films and 6.25 N at 70 ^{o}C for 7 hours for CR-39 films. After the chemical treatment of the CR-39 and LR-115 type II detectors [Misdaq, 1996].The visual counting of alpha particles tracks (i.e. N_G^{CR}, N_G^{LR}) are carried out by means of an optical microscope.

The global alpha particle track densities that registered on CR-39 and LR-115 detectors (i.e. ρ_G^{CR} and ρ_G^{LR}) are calculated according to the following equations

$$\rho_G^{CR} = \frac{N_G^{CR}}{A_G \times t_G} \qquad \text{---------- (1)}$$

And

$$\rho_G^{LR} = \frac{N_G^{LR}}{A_G \times t_G} \qquad \text{---------- (2)}$$

Where A_G is the global area of view and t_G is the global time of irradiation. Hence, the global density of tracks due to the α -particles emitted by radon, thoron and their daughters, registered on the CR-39 SSNTD is then

$$\rho_G^{CR} = A_c^{222}\left(Bq.\ cm^{-3}\right)\left[\sum_{i=1}^{3} k_i\ P_i^{CR}\ R_i + \frac{A_c^{220}}{A_c^{222}}\ \sum_{i=1}^{4} k_i\ P_i^{CR}\ R_i\right] \qquad \text{…….. (3)}$$

The global density of tracks per unit time (tracks.cm^{-2}.s^{-1}) due to the α -particles of the radon and thoron groups registered on the LR-115 type II SSNTD is then equal to:

$$\rho_G^{LR} = A_c^{222}\left(Bq.\ cm^{-3}\right)\left[3\ P^{LR}\ \Delta R + 4P^{LR}\ \Delta R \frac{A_c^{220}}{A_c^{222}}\right] \qquad \text{……..……. (4)}$$

Combining eqs.(3) and (4), the following relationship between track densities and thoron to radon ratio is [Misdaq, 1996]:

$$\frac{\rho_G^{CR}}{\rho_G^{LR}} = \frac{\sum_{i=1}^{3} k_i\ P_i^{CR}\ R_i + \frac{A_c^{220}}{A_c^{222}} \sum_{i=1}^{4} k_i\ P_i^{CR}\ R_i}{3\ P^{LR}\ \Delta R + 4\ P^{LR}\ \Delta R\ \frac{A_c^{220}}{A_c^{222}}} \qquad \ldots\ldots\ldots\ldots (5)$$

Where, P_i^{CR} represents the probability for an alpha-particle of energy $E_{\alpha i}$ and index i emitted at a distance x from the detector to reach and be registered on the CR-39 SSNTD [Misdaq, 1996].

The values of P_i^{CR} for each index i are shown in Table (1) and the values of P^{LR} for each residual thickness are shown in Table (2).

Knowing ρ_G^{CR} , ρ_G^{LR} , P_i^{CR} and P^{LR} one can determine the A_c^{220} / A_c^{222} ratio and consequently the thoron A_c^{220} and A_c^{222} activities of the studied sediment samples have been evaluated.

Results and discussion

The A_c^{220} / A_c^{222} ratios as well as radon activity per unit volume for the samples studied have been determined by using Eqs (3), (4) and (5). The error on track density counting is smaller than 7 % for samples studied. Two major marshes in Basrah Governorate, Al-Qurna marsh and Al-Mediena marsh. In Al-Qurna marsh twenty village or area have been studied to measure the radon activity each one was taken as station. Table (3) shows the name of station, the global track density of LR-115 type 2 (ρ_G^{LR}), the global track density of CR-39 (ρ_G^{CR}), the ratio of A_c^{220} / A_c^{222} , station number and the activity of ^{222}Rn (A_c^{222}).

From Table(3) it is clear that the observed the activity of sediments in Al-sedied area (station 9) has the highest value 10740 Bq m^{-3} while the lowest value 1985 Bq m^{-3} of activity of Radon in Bet Aoffi (station 18).

Fig.(3) shows the Radon concentration of the sediment samples of Al-Qurna marshes in Basrah governorate as a function of station number. From the values in Fig.(3) one can observe that the radon activity in all stations of Al-Qurna marshes are within the natural limits [ICRP, 1987].

Table (4) shows the radon concentration in the sediments samples of Al-Mediena marshes in Basrah governorate. Twenty two stations in this area was investigated. Station number 7,17 and 19 have radon concentrations (18329.47 Bq m^{-3}), (17163.19 Bq m^{-3}) and (16564.36 Bq m^{-3}) respectively, these stations which exceeds the allowed level, while all other stations haves radon concentration within the natural limits. The lowest value (1769 Bq m^{-3}) of activity was found in Umelha (station 9).

Fig.(4) shows the radon concentration of the sediment samples of Al-Mediena marshes in Basrah governorate. From this figure one can easily observe a maximum differences between the maximum value of activity in station 7 and minimum value in station 9.

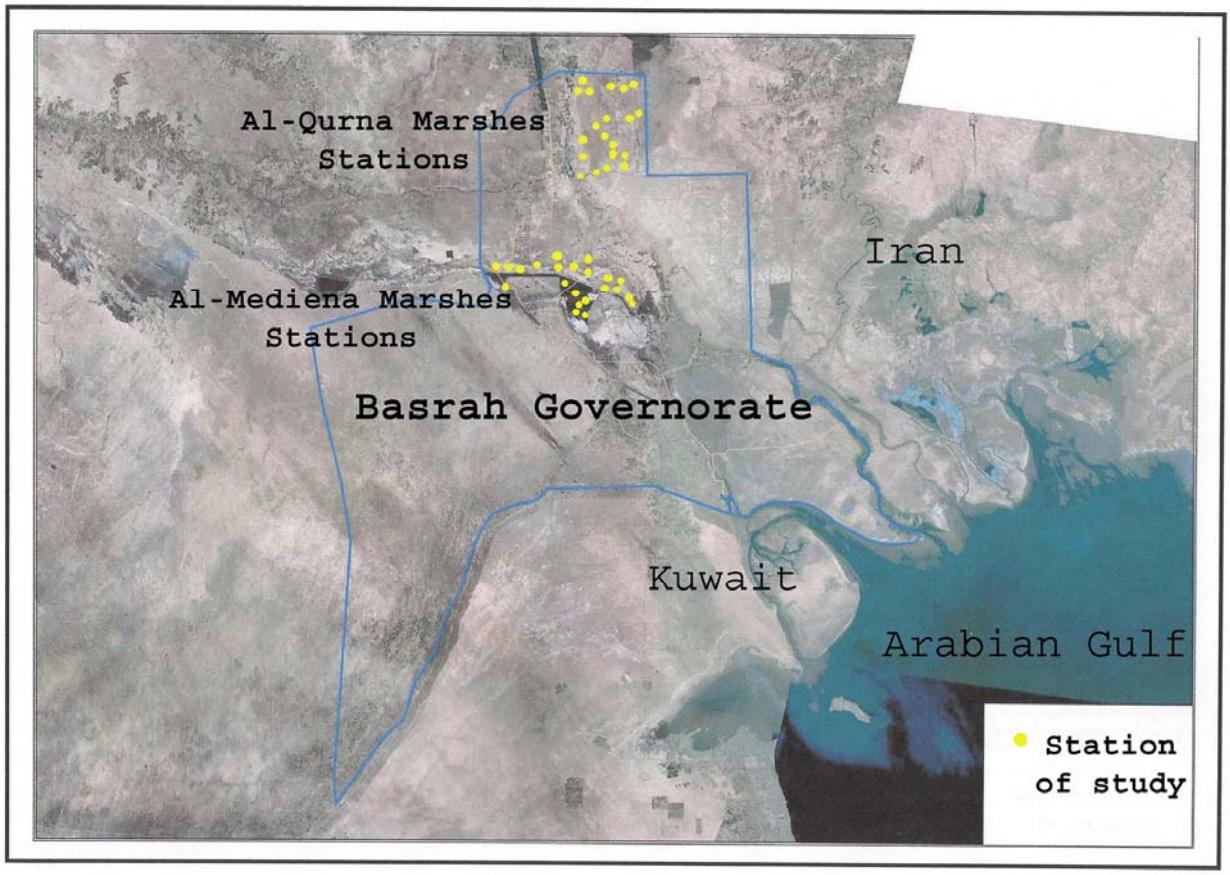
This figure reflects great variability of radon concentration in each station, explaining many parameters effect on the result. One of these parameters is due to the structure of sediments, when contents of radium and uranium are high, the radon concentration was increased . The uranium concentration measurement in the anomalous areas are in progress.

Conclusion

In this investigation, the activity of radon levels have been measured in the sediments of Basrah governorate marshes. Like several other reported data the maximum activity (18329 Bq m^{-3}) have been observed in Al-Heyadir (station 7) in Al-Mediena marshes, while the minimum activity (1769 Bq m^{-3}) has been observed in Umelha (station 9) also in Al-Mediena marshes.

It may be mentioned here that Iraq has variable geologies, it is therefore suggested that an extensive study of uranium and thorium concentration in sediments throughout the marshes may be initiated. Determination of the seasonal variations in the radon concentration levels is also necessary to be carried out.

Despite the limitation of existing data the observational and experimental data presented here is the first investigation and study provided a basis for the radon map in Iraq.



in Iraq.

Fig.(1): Stations of study in Basrah Governorate.

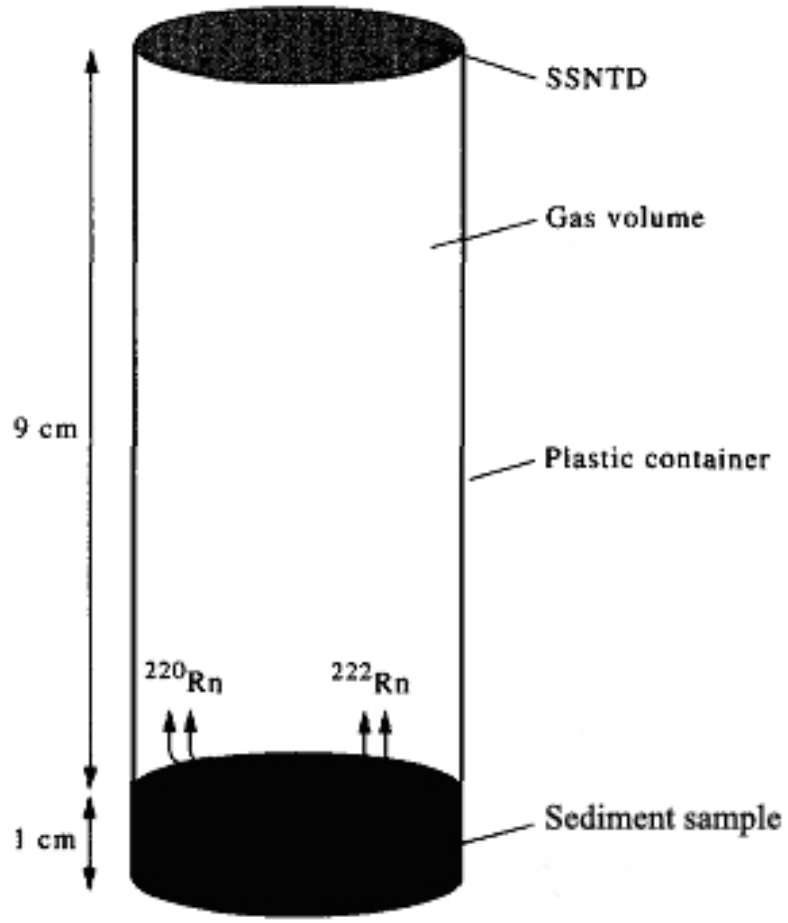


Fig.(2):Arrangement of the solid state nuclear track detector films placed at a distance of 9 cm above a sediment sample in a cylindrical plastic container of 2 cm radius.

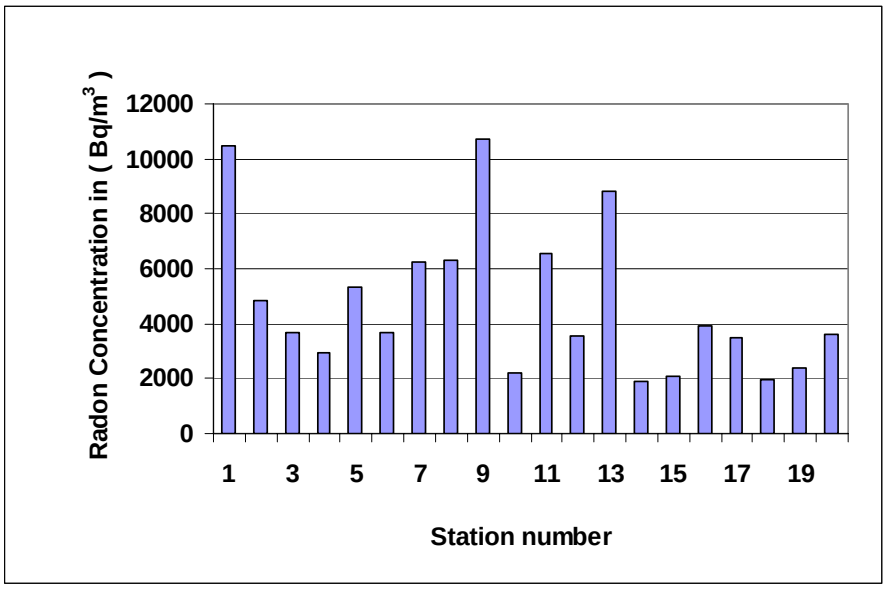


Fig.(3): The Radon concentration of the sediment samples of Al-Qurna marsh in Basrah governorate.

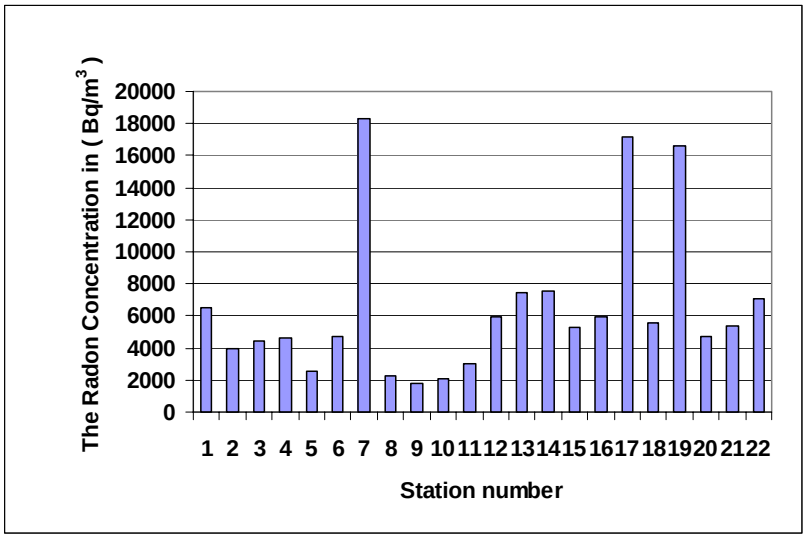


Fig.(4): The Radon concentration of the sediments samples of Al-Mediena marshes in Basrah governorate.

Table (1): Data obtained for the probability (P_i^{CR}) for radon group α -particles and thoron group α -particles to be registered on the CR-39 SSNTD for the gas volume of the α -particles of energy $E_{\alpha i}$ and index i in the gas volume [Misdaq, 1996].

Nuclide	$E_{\alpha i}$, MeV	R_i, cm	P_i^{CR}, $\times 10^{-3}$
Radon group α-particles			
^{222}Rn	5.49	3.90	2.871
^{218}Po	6.00	4.65	3.383
^{214}Po	7.68	6.62	4.440
Thoron group α-particles			
^{220}Rn	6.28	4.80	3.391
^{216}Po	6.78	4.75	3.433
^{212}Bi	6.08	5.45	3.527
^{212}Po	8.78	8.36	5.711

Table (2): Values of the probability (P^{LR}) for the α -particles of the radon and thoron groups to be registered on the LR-115 SSNTD for different residual thickness for (LR-115 films) for the gas volume of the water samples. R_{min} and R_{max} are the α -particles ranges in the gas volume which correspond to the lower and upper ends of the energy window [Misdaq, 1996].

Residual thickness, μm	R_{min}, cm	R_{max}, cm	$P^{LR} \times 10^{-3}$
3	0.46	3.83	203.299
4	0.61	3.52	11.302
5	0.80	3.44	4.329
6	0.98	2.71	1.536
7	1.07	2.66	1.405
8	1.29	2.53	1.336
9	1.42	2.31	0.267
10	1.60	2.02	0.191

Table (3): The radon concentration in the sediment samples of Al-Qurna marsh in Basrah governorate.

Station Number	***Name Of Station***	$\rho_G^{LR} \times 10^{-5}$ ***(tr .cm $^{-2}$.s $^{-1}$)***	$\rho_G^{CR} \times 10^{-5}$ ***(tr .cm $^{-2}$.s $^{-1}$)***	A_c^{220} / A_c^{222}	A_c^{222} ***(Bq.m^{-3})***
1	Al-Mayah (1)	76.097	121.908	0.84	10467.92
2	Al-Mayah (2)	29.589	47.609	0.583	4854.817
3	Al-zergan (1)	25.321	40.616	0.757	3675.058
4	Al-zergan (2)	14.267	23.113	0.313	2935.315
5	Bet Al-Zegmi (1)	31.865	51.303	0.553	5348.959
6	Bet Al-Zegmi (2)	24.752	39.728	0.718	3686.226
7	Al-Sedied (1)	48.062	76.901	0.932	6249.206
8	Al-Sedied (2)	30.164	48.886	0.301	6280.235
9	Al-Sedied (3)	80.748	129.262	0.894	10740.68
10	Al-Routa (1)	16.848	26.957	0.931	2192.123
11	Al-Routa (2)	38.172	61.491	0.527	6536.1
12	Al-Routa (3)	14.585	23.774	0.147	3557.371
13	Al-Hlechya (1)	67.878	108.607	0.932	8826.061
14	Al-Hlechya (2)	9.076	14.718	0.282	1923.638
15	Al-Hlechya (3)	10.417	16.852	0.359	2053.812
16	Bet Aoffi (1)	23.166	37.299	0.551	3895.399
17	Bet Aoffi (2)	20.271	32.658	0.522	3487.094
18	Bet Aoffi (3)	15.268	24.43	0.932	1985.41
19	Mzearah (1)	18.164	29.069	0.916	2384.78
20	Mzearah (2)	20.534	33.104	0.492	3617.933

Table (4): The radon concentration in the sediments samples of Al- Mediena marshes in Basrah governorate.

Station Number	*Name Of Station*	$\rho_G^{LR} \times 10^{-5}$ *(tr .cm $^{-2}$.s $^{-1}$)*	$\rho_G^{CR} \times 10^{-5}$ *(tr .cm $^{-2}$.s $^{-1}$)*	A_c^{220} / A_c^{222}	A_c^{222} *(Bq.m^{-3})*
1	Al-Direiwishi (1)	31.659	51.281	0.317	6484.79
2	Al-Direiwishi (2)	23.81	38.336	0.551	4002.711
3	Al-Ajera (1)	25.38	40.917	0.491	4471.806
4	Al-Ajera (2)	25.641	41.362	0.468	4605.122
5	Um Hellawi (1)	19.362	30.979	0.932	2517.802
6	Um Hellawi (2)	25.38	40.988	0.421	4740.971
7	Al-Heyadir (1)	96.132	155.352	0.397	18329.47
8	Al-Heyadir (2)	16.222	25.99	0.834	2239.526
9	Umelha (1)	12.821	20.54	0.835	1768.977
10	Umelha (2)	15.961	25.537	0.931	2075.969
11	Al-Maaber (1)	19.362	31.113	0.651	3022.797
12	Al-Maaber (2)	28.258	45.803	0.296	5906.882
13	Nahar Saleh (1)	30.613	49.899	0.147	7458.914
14	Nahar Saleh (2)	32.706	53.192	0.202	7513.669
15	Al-Sheteat (1)	22.076	35.95	0.169	5249.739
16	Al-Sheteat (2)	25.642	41.725	0.188	5977.155
17	Um Al-Hoash (1)	86.193	139.483	0.348	17163.19
18	Um Al-Hoash (2)	22.055	36.007	0.113	5587.548
19	Al-Jela' (1)	93.291	150.436	0.482	16564.36
20	Al-Jela' (2)	19.688	32.064	0.168	4689.073
21	Al-Khenzeri (1)	26.688	43.194	0.344	5334.5
22	Al-Khenzeri (2)	33.753	54.721	0.289	7100.444

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