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Original Research Article

Assessment of radon level in soil samples from Manzala Lake East Nile Delta, Egypt using passive technique

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ABSTRACT

Background: Radon is an important natural radioactive factor harmfully, because radon is radioactive gas comes from the natural decay of uranium series deposits in soil, which is harmful on human and environment.
Methods: The radon concentrations and exhalation rate were measured using passive technique with CR-39 and LR-115 detectors in twenty soil samples from and around Manzala Lake in the North Nile Delta, Egypt.
Results: From the results the average value of radon concentration ranged from 874.51 to 136.99 Bqm^{-3}.
Conclusions: The present study can be used as reference information to detect any harmful radiation that would affect the human and assess any changes in the radioactive background in the studied area.

Keywords: Dose, Radon, Soil, CR-39, Passive technique

INTRODUCTION

Naturally occurring radionuclides enter the human body, mainly by inhalation of radon, thoron gases by ingestion of primordial radionuclides and also their progeny.[1] Radon is produced through α-decay of uranium series in the soil is the only gaseous decay in this series as a noble gas, part of ^{222}Rn emitted from the soil grains into the air and diffuses to the atmosphere. Radon is an important natural radioactive gas harmfully influencing the human population, because radon gas comes from the natural decay of uranium series deposits in soil, which is very harmful on human and the environment.[2] The internal exposure is caused by ^{222}Rn and its short-lived decay products. Radon may be easily inhaled and its descendants may be deposited in tissues of the respiratory tract.[3] Radiation include external sources, like cosmic rays and radioactive materials in the ground, internal sources resulting from inhalation and ingestion of naturally occurring radioactive materials in air. Passive technique, which used in the present work based on the registration of alpha tracks from ^{222}Rn on an alpha sensitive track detector that was developed for radon exploration. The detector is exposed to the soil gas for a specific period of time. The alpha tracks are registered on the detector and the track density gives a measure of ^{222}Rn concentration in the soil. As it is a very simple technique, it can be used easily in field studies, since they do not require to electronic system.

Manzala Lake is considered one of the most important coastal lakes and the largest lake in the northern edge of the Nile Delta, Egypt. It is found between (31˚ 50'- 32˚ 15') E and (31˚ 00'- 31˚ 35') N and the lake area covers about 1071 km^2, with a maximum length of 64.5 km and a maximum width of 49 km. It is bordered by Port Said from the north east Damietta branch of Nile from west, also from north Mediterranean sea and El-Sharkia Governorate on the south. The lake receives a high load of different polluted waste water, including sewage water, industrial and agricultural waste from many drains, such as Bahr El-Baqar, Ramses, El-Serw, El-Matria, Faraskur, Lissa El-Gamalia and Hados, so that Manzala Lake is considered one of the most polluted lakes in Egypt.[4-6]

The main objective of this study is mainly to estimation radon concentration and surface exhalation rate in soil samples from and around Manzala Lake in the North Nile Delta, Egypt, in order to assess the change in the radioactive background level in Manzala Lake, which receives greet quantity of agricultural, industrial, municipal and domestic waste water, in addition to navigation and fishing activities.

METHODS

Twenty samples from different locations from and around Manzala Lake were collected. The samples were measured using passive technique to determine radon concentration and exhalation rate with CR-39 and LR-115 detectors. All samples were dried in air for four days and dried at 110°C for 3 hour in oven, sieved by 1 mm mesh, weighted and sealed for 72 days in cylindrical containers made from plastic with dimensions of 9 cm in diameter and 16 cm in high. Each sample container was capped tightly to an inverted cylindrical plastic cover.

CR-39 and LR-115 detectors of area 1.5 cm × 1.5 cm fixed at the bottom center of the inverted plastic cover. After the exposure period CR-39 and LR-115 detectors were removed carefully from the can. CR-39 detector etched in NaOH solution with condition 6.25 N at 70 ± 1°C for 7 hours. After etching CR-39 detectors were washed in distilled water and then dipped for a few minutes in a 3% acetic acid solution, washed again with distilled water and finally dried.[7] In the case of LR-115 detector etched in 2.5 N of NaOH in water bath at 60 ± 1 °C for 1 hour. After the chemical etching LR-115 were washed in distilled water and then placed in a solution of (50 ml water + 50 ml ethyl alcohol) again washed using water and dried in air. After etching CR-39 and LR-115 detectors, the tracks were counted using an optical microscope with a magnification of 640 X. The background of CR-39 track detector was counted by optical microscope and subtracted from the count of all detectors.[8] The value of radon concentration in (Bqm^{-3}) at secular equilibrium given by the following equation:

$$C_{Rn} = \frac{\rho}{\eta T} \quad (1)$$

Where, C_{Rn} is radon concentration (Bqm^{-3}), ρ is the track density (track cm^{-2}), T is the exposure time (day) and η is the calibration coefficient of CR-39 and LR-115 detectors in (tracks cm^{-2}day^{-1}/Bqm^{-3}).[9]

Radon surface exhalation rate given by the relation**:**

$$E_A = \frac{CV\lambda}{A[T+\frac{1}{\lambda}(e^{-\lambda T}-1)]} \quad (2)$$

Where, E_A is exhalation rate (Bqm^{-2}h^{-1}), C_{Rn} radon concentration (Bqm^{-3} h^{-1}), λ radon decay constant (h^{-1}), V effective volume of the Can (m^3), A area covered by the Can (m^2) and T the irradiation time[10,11]. The annual effective dose rate (H_E) was calculated according to the following equation:

$$H_E\,(\text{mSv y}^{-1}) = C_{Rn}\,.D.\,H.\,F.\,T \quad (3)$$

Where, F=0.4 the indoor equilibrium factor between radon and its progeny, H is the indoor occupancy factor (0.8), D is the dose conversion factor (9×10^{-6} mSvh^{-1} per Bqm^{-3}) and T is the indoor exposure time in hours per year which, equal 7000 h y^{-1}.[3,12]

RESULTS

The description and disruption of sample locations in the studied area (Manzala Lake) were given by Table 1. The values of radon concentrations, surface exhalation rate and annual effective dose of the collected samples using CR-39 and LR-115 detectors as shown in Table 2.

The values of radon concentration ranged from 845.99 ± 21.71 to 135.34 ± 8.68 Bqm^{-3}, surface exhalation rate ranged from 0.11–0.69 Bqm^{-2}h^{-1} and the values of annual effective dose were ranged from 3.41-21.34 mSvy^{-1} using CR-39 detector. But in the case of LR-115 detector were 903.03 ± 41.69 to 138.64 ± 16.34 Bqm^{-3}, 0.11- 0.74 Bqm^{-2}h^{-1} and 3.50- 22.78 mSvy^{-1} for radon concentration, surface exhalation rate and annual effective dose, respectively. The results indicate that the sample no. 4 has a high value but sample no. 16 has low values of the measured samples.

Figure 1 gives the comparison between the values of radon concentration using CR-39 and LR-115 detectors. From the figure we find that sample no. 4 is higher than all samples, but sample no. 16 is lowest sample.

Figure 2, shows the correlation relation between radon concentrations and surface exhalation rate of radon using CR-39 detector, and the correlation coefficient equal 0.99. This is a good correlation between radon and surface exhalation rate. In case of LR-115 the correlation coefficient equal 0.99 as shown in Figure 3. The comparison between the values of annual effective dose using CR-39 and LR-115 detectors was given by Figure 4. The results agreement with the published data in different countries is given in Table 3.

DISCUSSION

The values of radon concentration in sample number four higher than sample number sixteen; this refers to the difference between the chemical composition and geological structure of the samples. Most of the indoor radon values lie in the range of action levels from 200 to 600 Bqm^{-3}.[24,25]

Table 1: The samples locations and description of the collected samples from Manzala Lake and its surrounding area.

Sample	Area name	Description	Latitude	Longitude
1	Damietta	Near El-Husania city	31° 23' 45"	31° 51' 33"
2	El-Rodah	End of Faraskour drain at the lake water	31° 21' 20"	31° 53' 15"
3	El-Serw	End of El-Serw drain at the lake water	31° 17' 51"	31° 52' 48"
4	El-Gamalyia	End of the El-Gamalyia drain at the lake water	31° 15' 30"	31° 53' 09"
5	Lissa El-Gamalyia	Near Island drain and bar El-Ezby soliman	31° 16' 56"	31° 56' 44"
6	Abwat	Mid of the lake, clear water area	31° 18' 34"	31° 59' 02"
7	El-Nassima 1	End of the Long drain mixing with lake water	31° 15' 20"	31° 59' 46"
8	Bahr El-Baqar 1	End of Bahr El-Baqar drain at the lake water	31° 09' 29"	32° 04' 35"
9	El-Mataria	Near the outlet of El-Mataria drain	31° 11' 26"	32° 02' 56"
10	Hados drain	End of Hados drain mixing with lake water	31° 09' 20"	32° 05' 36"
11	Ebn Salam Island	Near El-Mataria city	31° 11' 09"	32° 05' 01"
12	El-Legan	Area in the mid of the lake with clear water	31° 13' 49"	32° 05' 47"
13	Bahr El-Baqar2	Away from port Said road about 10 Km	31° 11' 50"	32° 10' 22"
14	Port Said	Near Port Said canal	31° 13' 30"	32° 13' 24"
15	El-Hamra	Area of Brackish water near Mediterranean sea	31° 15' 20"	32° 15' 01"
16	El-Ghamil	At boughaz bridge connect with Mediterranean sea	31° 15' 32"	32° 12' 45"
17	Fyala Island	Near Port Said	31° 15' 07"	32° 09' 46"
18	Kassab Island	The mid of the lake	31° 16' 25"	32° 06' 49"
19	El-Nassima 2	The mid of the lake	31° 17 48"	32° 03' 18"
20	El-Tabia	Away from international coastal road about 5 Km	31° 20' 25"	32° 02' 27"

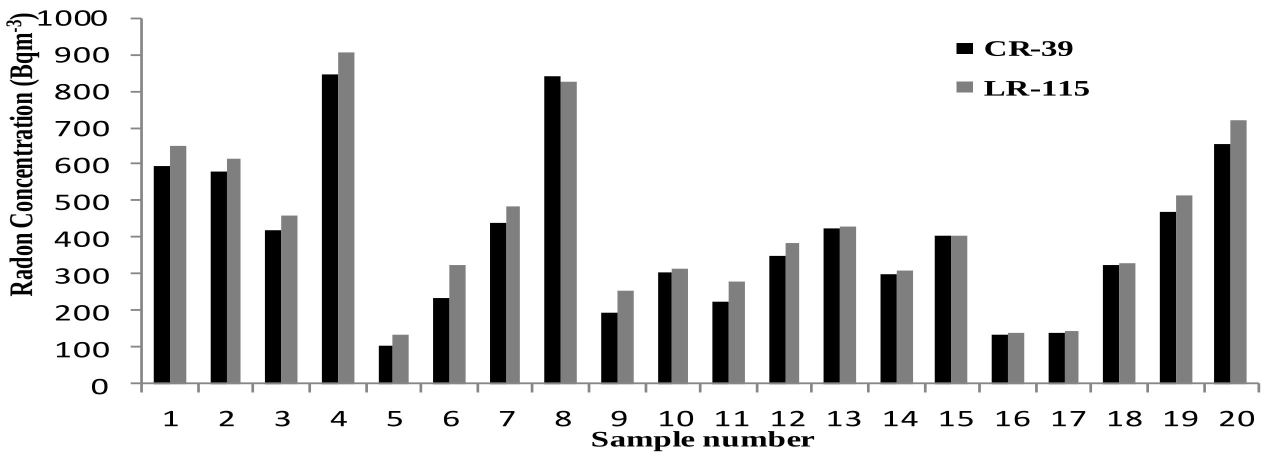

Figure 1: The comparison between the values of radon concentration using CR-39 and LR-115 detectors.

Table 2: The comparison between the values of radon concentrations, surface exhalation rate and annual effective dose of soil samples using CR-39 and LR-115 detectors.

S. no.	CR-39			LR-115		
	C_{Rn} (Bqm^{-3})	E_A ($Bqm^{-2}h^{-1}$)	H_E ($mSvy^{-1}$)	C_{Rn} (Bqm^{-3})	E_A ($Bqm^{-2}h^{-1}$)	H_E ($mSvy^{-1}$)
1	593.13 ± 18.18	0.48 ± 0.01	14.96	652.53 ± 35.45	0.53 ± 0.03	16.46
2	581.94 ± 18.00	0.47 ± 0.01	14.68	614.09 ± 34.39	0.50 ± 0.03	15.49
3	422.15 ± 15.33	0.35 ± 0.01	10.65	462.05 ± 29.83	0.38 ± 0.02	11.66
4	845.99 ± 21.71	0.69 ± 0.02	21.34	903.03 ± 41.69	0.74 ± 0.03	22.78
5	103.01 ± 7.58	0.08 ± 0.01	2.60	134.67 ± 16.11	0.11 ± 0.01	3.40
6	232.79 ± 11.39	0.19 ± 0.01	5.87	323.41 ± 24.95	0.26 ± 0.02	8.16
7	438.27 ± 15.62	0.36 ± 0.01	11.06	485.12 ± 30.56	0.40 ± 0.02	12.24
8	839.89 ± 21.63	0.687±0.02	21.19	827.88 ± 39.92	0.68 ± 0.03	20.89
9	193.29 ± 10.37	0.16 ± 0.01	4.88	255.95 ± 22.20	0.21 ± .02	6.46
10	305.79 ± 13.05	0.25 ± 0.01	7.71	312.00 ± 24.50	0.26 ± 0.02	7.87
11	222.76 ± 11.14	0.18 ± 0.01	5.62	277.28 ± 23.10	0.23 ± 0.02	7.00
12	347.53 ± 13.91	0.28 ± 0.01	8.77	384.92 ± 27.23	0.32 ± 0.02	9.71
13	422.69 ± 15.34	0.35 ± 0.01	10.66	431.30 ± 28.81	0.35 ± 0.02	10.88
14	299.07 ± 12.91	0.24 ± 0.01	7.55	308.04 ± 24.35	0.25 ± 0.02	7.77
15	407.10 ± 15.06	0.33 ± 0.01	10.27	406.25 ± 27.97	0.33 ± 0.02	10.25
16	135.34 ± 8.68	0.11 ± 0.01	3.41	138.64 ± 16.34	0.11 ± 0.01	3.50
17	137.04 ± 8.74	0.11 ± 0.01	3.46	142.36 ± 16.56	0.12 ± 0.01	3.59
18	322.45 ± 13.40	0.26 ± 0.01	8.14	329.12 ± 25.18	0.27 ± 0.02	8.30
19	467.28 ± 16.13	0.38 ± 0.01	11.79	514.14 ± 31.46	0.42 ± 0.03	12.97
20	655.48 ± 19.11	0.54 ± 0.02	16.54	721.97 ± 37.28	0.59 ± 0.03	18.21

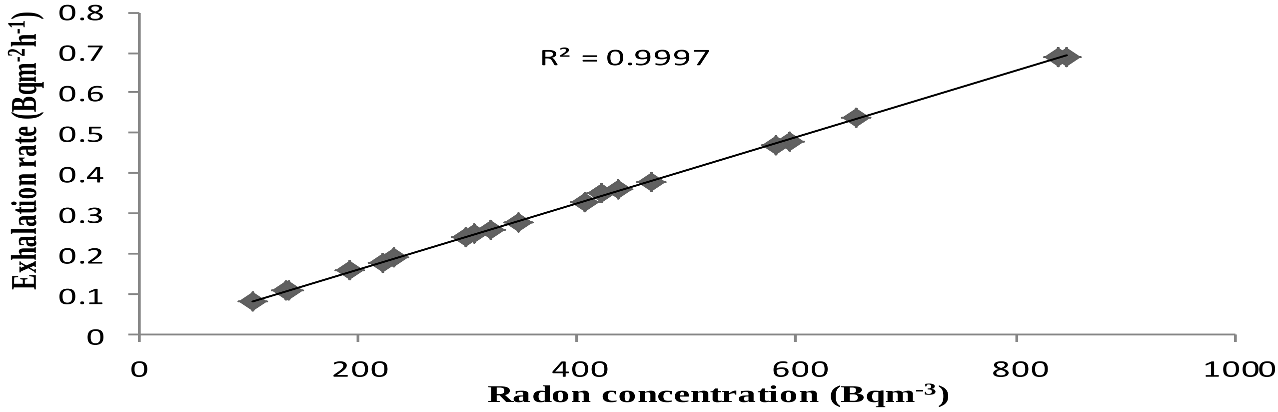

Figure 2: The correlation relation between radon concentration and surface exhalation rate using CR-39 detector.

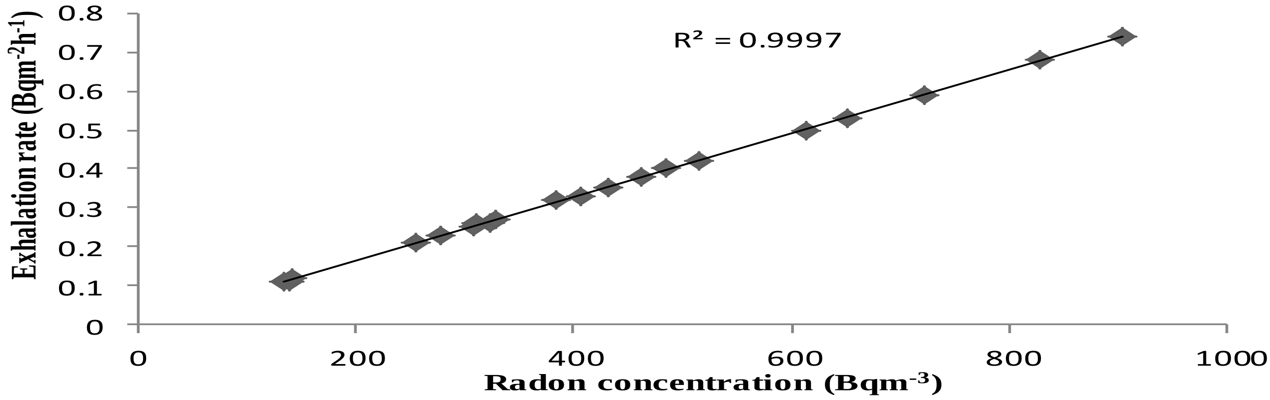

Figure 3: The correlation relation between radon concentration and surface exhalation rate using LR-115 detector.

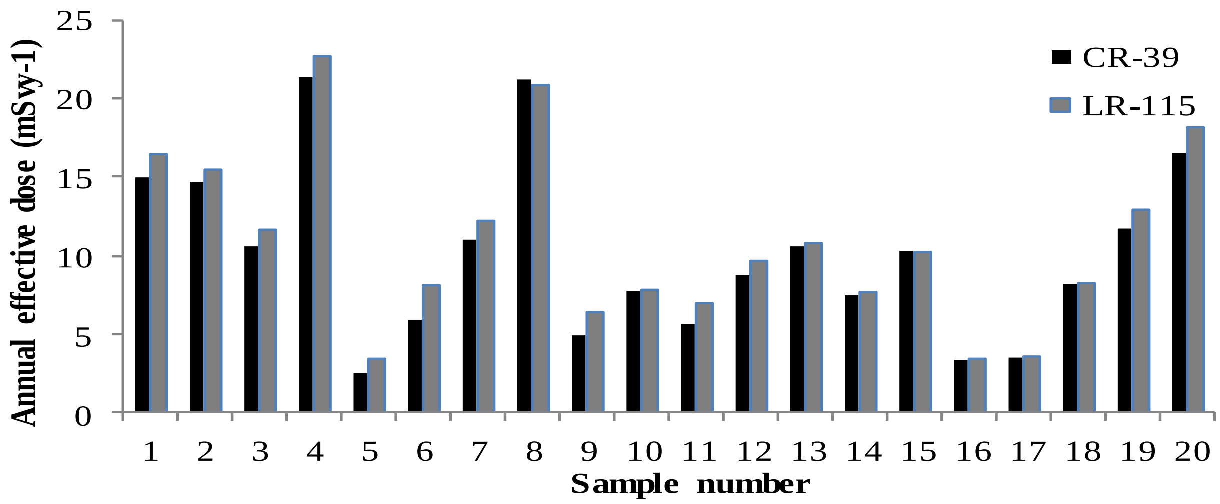

Figure 4: The comparison between the values of annual effective dose using CR-39 and LR-115 detectors.

Table 3: The comparison between the obtained results and the published data in different countries for soil samples.

Country	C_{Rn} (Bqm^{-3})	References
Egypt	717	8
Egypt	36.98- 576.18	13
Algeria	285	14
Libya	516	15
Iraq	478	16
Iraq	616.6	17
India	448	18
India	457	19
India	1117	20
India	2200	21
Turkey	1795	22
Nepal	2321	23
Egypt	136.99- 874.51	The present study

The average values of radon concentration in the samples are near the recommended limit 800 Bqm^{-3} which, reported by ICRP.[26] This value is below the radon reference level, which ranges from 200-600 Bqm^{-3} and action levels for workplaces of 500-1500 Bqm^{-3} as recommended by ICRP.[27] The obtained results with each other of radon concentrations using CR-39 and LR-115 detectors are consistent; while the percentage of errors in CR-39 are lower than LR-115. The percentage of error, which is referred to the partial sensitivity of the detectors, detector material, track density, the etching and counting techniques. CR-39 detector is widely used to measure radon and considered as the best option to measure the indoor radon concentration.

The correlation relation between radon concentration and exhalation rate using CR-39 and LR-115 detectors is linear relationship, because the values of surface exhalation rate depend on radon concentration since the volume of the cup, the area of the sample and decay constant of radon are the same for all samples. A positive correlation has been observed between radon concentration and surface exhalation rate in soil samples. The radon exhalation rate study is important for understanding the relative contribution of the material to the total radon concentration found in the soil samples and helpful to study radon health hazard effects. The average values of annual effective dose near the action levels (3-10) mSvy^{-1} recommended by ICRP and the dose limit of the permissible effective dose of occupational radiation exposure is 20 mSvy^{-1} in all European countries.[27,28].

CONCLUSION

The main aim of this study was to determine radon concentration and exhalation rate in the soil samples from Manzala Lake northern of the Nile Delta, Egypt using solid state nuclear track detectors. It is important to study the distribution of radon concentration in sediment samples of Manzala Lake. The results clearly demonstrate that Manzala Lake is highly contaminated with radon concentration due to the continuous discharge of different pollutant materials into it, which play an important role in causing a severe pollution in the studied area. The average values of radon concentrations have ranged from 874.51- 136.99 Bqm^{-3} and surface exhalation rate from 0.11- 0.72 Bqm^{-2}h^{-1} and the annual effective dose of the sample are 3.40 - 22.06 mSvy^{-1}. The obtained results can be used to assess any changes in the radioactive background level due to geological processes in the investigated area. The present study can be used as reference information to assess any changes in the radioactive background level in Manzala Lake and detect any harmful radiation that would affect the human.

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Conflict of interest: None declared
Ethical approval: The study was approved by the institutional ethics committee

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