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Estimation of Radon gas concentration in soil and drinking water supply samples of Kirkuk governorate, Iraq

Muaiad Tahir Ahmed[1], Mohamed A, Najemalden[2] , Ali A, Abdulwhab[3] , Rehab T.Ahmed[4]

1 Diyala university
2,3,4 Ministry of environment

Abstract

Radon gas is the second cause of lung cancer and it is found naturally in rocks, soil ground and surface water. In this study, Radon gas concentration measurements were performed in (39) drinking water and (29) soil samples for Kirkuk City. It is found that the value of Radon (Rn) concentration in drinking water ranged from (0.07 -5.01) Bq /L with an average of (0.97) Bq/L. These results showed that Radon concentration in Kirkuk City drinking water are within the United State Environmental Protection Agency(EPA) and World Health Organization(WHO) standards maximum contaminated level (MCL) of 11 Bq /L. The finding:- of this study refer that no risk from exposure to Radon gas in Kirkuk drinking water supply. From other hand, Radon in soil results showed that mean values was(381.65± 189) Bq/m^3, with maximum and minimum value 883and 87 Bq/m^3 respectively. This results lied within the allowable standards adopted by International Commissions of Radon Protection(ICRP) which is (200-800) Bq/m^3 . By comparing the results of present study with other local studies in different sites all over Iraq, it can be noticed that the finding of this study were greater than most of other studies results. That difference can be explained due to geological structure diversity of different governorate in Iraq, as Radon gas generated from soil and correlate strongly to soil structure and rock types.

Introduction

Human beings are exposed to two source of radiation in their life: natural and manmade radiation, natural sources: include radioactive radon , radioisotopes with along half – life , such as potassium in the body , cosmic rays and some rocks, natural sources of radiation account for 82% of total exposure for humans beings [1]. Radium is a common radioactive element , one of whose decay , Radon gas , poses health concerns as Radon is the second cause of lung cancer after smoking[2]. Radon generates from rock , soil and underground water as gas. Radon emanating from soil fills the atmosphere but eventually transmutes to other elements and is removed . Radon gas has a half-life as short as 3.82 day. it is difficult to detect Radon because it's a colorless and odorless gas. Its atomic number is (86) , boiling point (-61.8) c^0 and density of($9.73 \frac{kg}{m^3}$), so it is heavier than air about 8 times, because of that Radon will stay in air of closed areas and make health hazardous [3]. Radon gas can diffuse or be transported to some distance through fissures in the rock structure and find its way into the soil and surrounding materials . Therefore, Radon measurement is the most promising method for detecting uranium deposits [4].

It was not until the early 1970s that radon potential hazard from the inhalation of Radon gas and the daughter progeny in the domestic as urban environment was first identified. In the past, contamination of air by Radon was believed to be a problem only for uranium and phosphate miners. However, it has recently been recognized that homes and buildings far away from uranium or phosphate mines can also exhibit high concentration of radon [5]. Radon exposure has been linked to lung carcinogenesis in both human and animal studies. It has also been associated with the development of acute myeloid and acute lymphoblastic leukemia and other cancers [6]. Periodical monitoring of radon concentrations had been

emphasized by many international studies. They proved that the inhalation of short lived decay product of Radon accounts for about one half(1/2) of the effective dose equivalent from all natural source of radiation and sometimes lead to cause cancer for human especially lung cancer [7]. The recent key European studies estimated that the risk of lung cancer in human being increased by 16% per 100Bq/m^3 increase in Radon concentration. The dose-response relation seems to be linear without evidence of a threshold , that mean the lung cancer risk increase proportionally , with increasing radon exposure, from other hand , the new results find if a threshold exists it should not be higher than 150Bq/m^3 [8].

Recent studies showed that background level of radon in outdoor air of most American homes are quite low, ranging from (0.1-15) Bq/ m^3 . EPA (Environmental Protection Agency of United States) recommends home to be fixed if the radon level is 150Bq/m^3 [9]. Usually Radon can be found in surface and ground water and then it leaches to drinking water, also, Radon can be exists in drinking water coming from natural spring as a source. Radon evaporates from water used in cooking and bathing and spread to air inside homes and buildings[10] . Radon concentration in water is typically of the order of 100 Bq/L. United State of America drinking water sources surveys, which were done in 2005 showed that 74% of samples had Radon concentration under 100 Bq/L, while 5% had values above 400 Bq/L [11] . The major source of Radon in drinking water supplies is well water or groundwater , surface water can be substituted for the groundwater if the Radon concentration was above the united states environmental protection agency Maximum Contaminated Level (MCL) of 11 Bq/L[12].

Materials and Methods:

Study area :- This study was conducted in Kirkuk city , north of Iraq. 28 samples of soil, and drinking water ,were examined for Radon concentration in different locations inside Kirkuk City . The location were selected to cover different kind of buildings such as :old and new homes, universities, offices and hospitals, to ensure good representing for Radon concentration in the study area. Figure (1) illustrated the sampling locations in the study area. Alpha-guard, professional Radon monitor, (PQ2000 pro) SAPHYMO Gmbh, model 2009, Germany, was used to measured Radon concentration which illustrated in figure (2), the device belong to the Ministry of Environment; Kirkuk Environment Directorate. The study was conducted from April /2013 till August /2015 to applied the Ministry of Environment working plan for Radon gas monitoring. Measuring time was one (1) hour per each sample , soil samples were taken with 20 cm depth according to Ministry of Environment/ Radiation Protection Center protocol for Radon monitoring.

Figure(1) illustrated the sampling location

Figure (2) Alpha guard professional radon monitor

Results and Discussion:

Radon concentration in soil, and drinking water are listed in table(1).

Radon in soil : The results showed that mean values was(381.65± 189) Bq/m^3, with maximum and minimum value 883and 87 Bq/m^3 respectively as illustrated in Fig (3). This results lied within the allowable standards adopted by International Commissions of Radon Protection(ICRP) which is (200-800) Bq/m^3 [13]. By comparing the results of this study with other local studies in different sites all over Iraq, which illustrated in table (2), it can be noticed that the finding of this study were greater than most of other studies results. That difference can be explained due to geological structure diversity of different governorate in Iraq, as Radon gas generated from soil and correlate strongly to soil structure and rock types [14].

Radon in drinking water: Radon concentration in drinking water mean value was (0.97±1.24) with maximum and minimum value 5.02and 0.07 Bq/L respectively. All results were lied within United State Environmental Protection Agency(US-EPA) standards of 11 Bq/L [12] .Figure (4), illustrated the above results. Comparing Radon concentration of the present study with other locals studies in different parts of Iraq were shown in table (3), the results of present study were close to most of the previous locals studies:. On the other hand, comparing concentration for recent study with international studies in different countries which shown in table (4).The correlation between soil and drinking water Radon concentration showed positive and weak correlation (R^2 =0.0054), indicates that Radon concentration in drinking water is not depend on soil type as most of drinking water in Kirkuk depend on surface water, see figure (5).

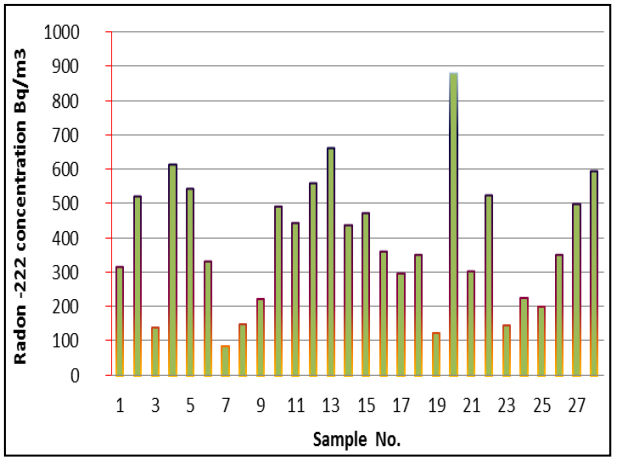
Conclusions: The results of the present study showed that Radon concentration ,both in soil and drinking water, were within international standards , indicating not need for further measurements.

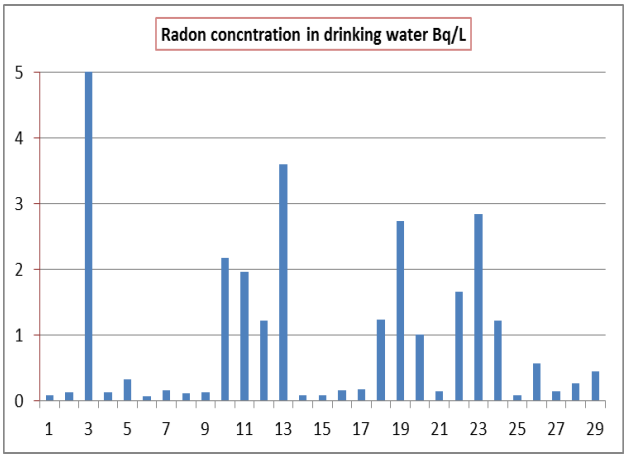
Table(1) sampling location and Radon concentration in soil and drinking water WATERwater

ID		– soil Bq/m3	drinking water Bq/l
R1	Kirkuk environmental directorate	320	0.09252
R2	Aden quarter-house	524	0.13364
R3	Kirkuk municipality garden	143	5.01664

R4	Al-Tayran square -house	615	0.13364
R5	Al-Mansur quarter-house	546	0.32896
R6	Khasa quarter-house	336	0.07196
R7	Raperen 2-house	87	0.16448
R8	Rahemawa quarter -house	153	0.11308
R9	Kirkuk technical institute	227	0.13364
R10	Debis town- AL –bdeer village	495	2.17936
R11	Dakuk town –health center	446	1.96348
R12	Al-Shfiaa medical center	561	1.22332
R13	Al-khadra quarter-house	664	3.598
R14	Kirkuk technical college	441	0.09252
R15	Shoraw hospital	476	0.08224
R16	Laylan town –medical center	363	0.16448
R17	Altun Kopree –medical center	299	0.17476
R18	North oil company -hospitals	353	1.2336
R19	Al-Qalam college	128	2.73448
R20	Dibs town –medical center	883	1.00744
R21	Kirkuk children hospitals	306	0.1542
R22	college of Nursing	526	1.65508
R23	college of science	149	2.83728
R24	Showan town -house	229	1.22332
R25	Kirkuk physical therapy center	203	0.08224

R26	Arafa medical center	353	0.57568
R27	Raperen 1-house	501	0.14392
R28	Kirkuk general hospital	597	0.26728
R29	Qernata quarter	144	0.45





Location/city	**Radon in soil Bq/m^3**	**Reference**
Duhok/Kurdistan region	342.3	[15]
Al-Anbar governorate / Hit town	266.4	[16]
Salahdin governorate	21.9	[17]
Salahdin governorate /dust storm sample	11.3	[18]
Al-Anbar/ Falluja town	95.78	[19]
Diyala governorate	23.5	
Baghdad	43.5	
Wasit governorate	48.6	
Samawa governorate /cement dust sample	10.6	[20]
Kirkuk	390	present study

Location/city	**Radon concentration in water Bq/L**	**Reference**
Basra governorate	1.25-21.07	21
Dhi-Qar governorate	1.63 - 6.96	22
Nenava governorate	0.83-1.75	23

Kirkuk city –residential areas	1.72-5.27	24
Anbar governorate	2.16-11.88	25
All over Iraq-bottled water	0.31-7.43	26
Al-Kifel town	0.03-1.15	27
Al-Kufa town	0.26- 5.66	28
Al-Kufa town	0.04-2.32	29
Erbel city,Kurdistan reigon	2.01- 4.69	30
Baghdad city	0.03-0.15	31
Hilla city	0.03-0.11	32
Kirkuk governorate/ different buildings	0.07- 5.02	Present study

Country	**Drinking water radon concentration Bq/L**	**Reference**
Palestine/ Nablus	0.9-1.3	[12]
Saudi Arabia	0.76-9.15	[33]
India	1.69-3.97	[34]
Syria	2.8-9.0	[35]
India	0.87-32.10	[36]
Turkey	2.7-34.11	[37]
Romania	0.5- 12.9	[38]
Iarq-Kirkuk	0.07- 5.02	Present tudy

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