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Effects of the deterioration of construction materials industry on the radioactivity background in Baghdad, Iraq

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Abstract

The potential presence of radioactivity in construction materials is considered a major health hazards for residents and inhabitants of various kinds of buildings, either directly or indirectly, via transition through air. The construction industry has been greatly affected by the numerous wars in Iraq since the 1980s. The most apparent problem is the lack of oversight which means that contractors have not followed safety standards.

This study investigated radioactivity levels in residential areas in Baghdad, Iraq in order to assess safety. A ɣ-ray spectrometer system was used based on a germanium high pure GHP detector. Indoor samples from residential areas built before and after 2003 were compared for their radioactivity. Similar comparisons were made for outdoor samples. Results showed indoor total radioactivity of 200 Bq/m^3 for new buildings as compared to 64.8 Bq/m^3 for older buildings. Outdoor findings showed a total radioactivity of 25.05 Bq/m^3 and 11.303 Bq/m^3 for new and old buildings, respectively.

Indoor radioactivity levels surpassed the United States' Environmental Protection Agency's limits, while outdoor samples showed much less radioactivity as compared to indoor ones, especially for ones considerably far..

Keywords: Air pollution; Baghdad; construction materials; radioactivity; radon.

1. Introduction

Exposure to radon and radon daughters are an important safety issue in dwellings made with brick, cement, gypsum, among others. Yeates, *et al.* (1970; 1972) studied radon progeny concentrations inside multi-story dwellings in the USA. Their study found out that inhabitants of basements suffered five times more respiratory illnesses than individuals occupying upper-floor offices. Upper floors seem to have better ventilation systems, as they are adopted by office management (ICRU, 2012). Studies reported 2.5-3.05 pCi/L concentrations of radon daughters resulting from construction materials in 14 Hungarian cities (Baskaran, 2016). Coating materials, such as plaster and asphalt, were found by Auxier, *et al.* (1974) were not effective at reducing the exposure rate from radon daughters (Girault and Perrier, 2011), According to Al Maliky (2011), plants have proven to be highly efficient against many gases and particulates. Many studies examined Baghdad, Iraq, for radon and radon progeny's potential effect on building inhabitants. Al Maliky, *et al.* (2010) found indoor concentrations in a 1960's-era office complex in Baghdad were less than that in other international locations. Nada, *et al.* (2015) studied indoor radon concentrations of fifteen dwellings in Baghdad. The study concluded that the average indoor concentrations did not exceed International Commission on Radiological Protection (ICRP) limits. Many other studies have been published regarding Baghdad and other Iraqi cities, yet none has discussed the classification of old premises from new ones, in order to examine the possible effect of imported regional cheap quality construction materials, after the overwhelming collapse of almost all Iraqi national factories for the various construction materials after the year 2003 invasion of the US army; more than ten big state factories in addition to many small state and private ones (Financial Tribune, 2018).

This study examines radon and radon progeny concentrations inside and outside newly constructed premises (after 2003) and in old ones in order to predict the possible impact of imported construction materials on the radioactivity background in Baghdad.

2. Methodology

Four indoor and two outdoor samples were collected from three old residential areas and other three newly structured ones; before and after 2003. Radioactivity levels were measured on both sides of Baghdad (Rasafa and Karkh) to get more accurate readings throughout the city. About 2 to 3 houses in each area were chosen as sampling locations. Outdoor sampling was carried out during null wind velocity in order to avoid contamination from outside areas. The air samplers were distributed at various heights inside each house. For outdoor locations, they were fixed around 1.4 to 2.0 m high. A gamma spectrometric system based on a 40% efficiency, GHP detector (Figure 1), was used to examine the particulates collected on the air sampler filters.

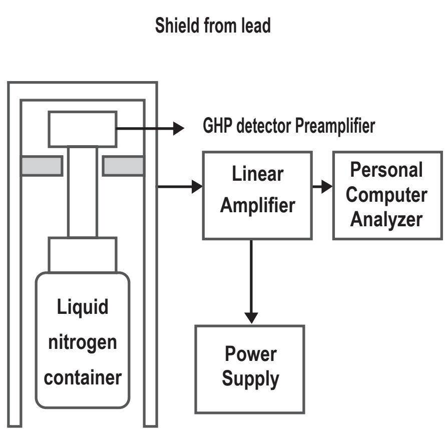

Fig. 1. Configuration of the Gamma spectroscopy system.

2.1 Calculations

The radioactivity concentrations of radon (^{222}Rn progeny), lead (^{214}Pb), and Bismuth (^{214}Bi) were determined in (Bq/m^3) by adopting the computer code Giant Dipole Resonance GDR-4. This code is based on the derivations that are mentioned by Chakrabarty *et al.* (2016), while Polonium (^{218}Po) was calculated by the equation:

$$A_{Po218} = 1.55\, A_{Pb214} \quad (1)$$

and hence, the ^{222}Rn concentration may be calculated as follows:

$$A_{\mathrm{Rn}} = \frac{0.38\, A_{Bi} + 0.514\, A_{Pb} + 0.106\, A_{Po}}{EF}, \quad (2)$$

where A is the activity. EF is the equilibrium factor for radon gas concentration (0.8 for outdoor exposure and 0.4 for indoor exposure) (Maghraby *et al.*, 2014).

3. Results and discussions

Tables 1, 2, and 3 show the results for the measured ^{214}Pb and ^{214}Bi and calculated ^{218}Po for samples from both old and new buildings.

Table 1. Measured and calculated outdoor radioactivity concentrations.

Location number	Radioactivity concentrations [Bq/m^3]			Note
	^{214}Pb	^{214}Bi	^{218}Po	
1	4.1	12.3	6.355	Old building
2	5.6	13.8	8.68	Old building
3	4.3	11.11	6.665	Old building
4	16.3	16.3	25.265	New building
5	6	24.9	24.18	New building
6	4.4	10.45	6.82	Old building
7	5.2	9.6	8.06	Old building
8	14.3	22.1	22.165	New building
9	3.25	9.87	5.0375	Old building
10	13.23	19.1	20.5065	New building
11	13.4	22.6	20.77	New building
12	12.7	20.83	19.685	New building

Table 2. Measured and calculated indoor (new building) radioactivity concentrations.

Location number	Radioactivity concentrations [Bq/m^3]		
	^{214}Pb	^{214}Bi	^{218}Po
1	69.2	80.1	107.26
2	65.08	77.12	100.874
3	72.4	83.08	112.22
4	61.7	71.2	95.635
5	58.05	69.2	89.9775
6	67.33	75.8	104.3615
7	59.5	69.3	92.225
8	68.3	85	105.865
9	70.2	84.2	108.81
10	67.88	82.33	105.214
11	65.8	72.8	101.99
12	56	67.94	86.8

Table 3. Measured and calculated indoor (old building) radioactivity concentrations.

Location number	Radioactivity concentrations [Bq/m^3]		
	^{214}Pb	^{214}Bi	^{218}Po
1	21.452	28.035	33.2506
2	20.1748	26.992	31.27094
3	23.2	28.53	35.96
4	19.127	24.92	29.64685
5	17.53	24.22	27.1715
6	20.2	26.53	31.31
7	16.11	25.02	24.9705
8	19.8	29.75	30.69
9	21.762	29.47	33.7311
10	21.0428	29.1	32.61634
11	18.232	25.48	28.2596
12	17.36	22.234	26.908

In Figure 2, the total radioactivity of ^{222}Rn for indoor results shows a significantly high concentration of indoor radioactivity in new buildings. The concentration reaches 200 Bq/m^3 (average of 183.1 Bq/m^3 and a standard deviation of 13.868). In contrast, the total radioactivity of ^{222}Rn maximum value for old buildings is about 64.8 Bq/m^3 (average of 58.7 Bq/m^3 and a standard deviation of 1.588). In other words, indoor concentrations for new buildings are about 3 times as high as those for old buildings. It is important to note that both new and old buildings share almost the same soil conditions. This means that soil is not causing the higher levels in new construction. The data suggest imported new construction materials have a huge influence on the radioactive background in the tested locations.

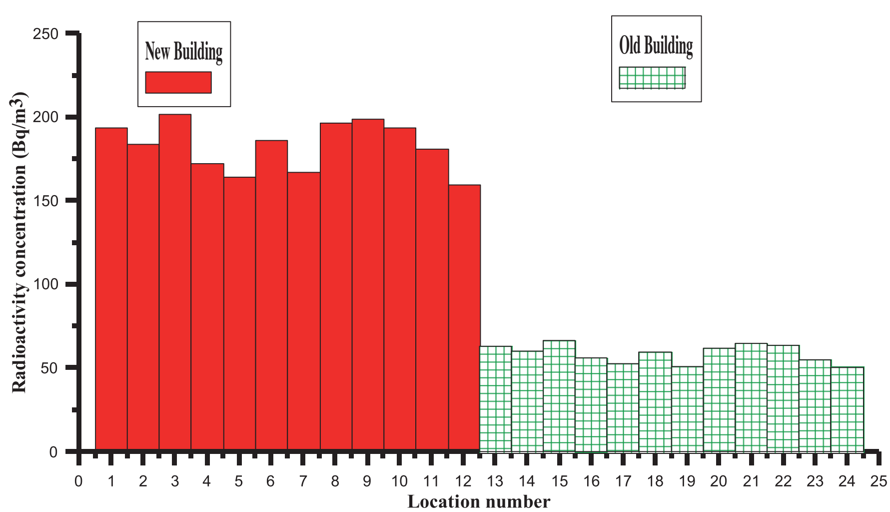

Fig. 2. Indoor ^{222}Rn radioactivity concentration for new and old buildings.

The case for outdoor results in Figure 3 shows that the maximum concentration in new buildings reached 25.05 Bq/m^3 (average 22.048 Bq/m^3 with a standard deviation of 1.56). In contrast, it was 11.303 Bq/m^3 (average 9.108 Bq/m^3 with a standard deviation of 1.14) for outside old buildings, in another sign for the impact of the new construction materials on rising the radioactivity background. The double value of outdoor concentrations for new neighborhoods as compared to old ones, also shows that outdoor environments are somehow affected by the high radioactivity emissions from indoor sources, especially closer to the buildings. However, the levels are not at a level which represents a high risk for the outdoor targets, as they are still less than the internationally stipulated limits.

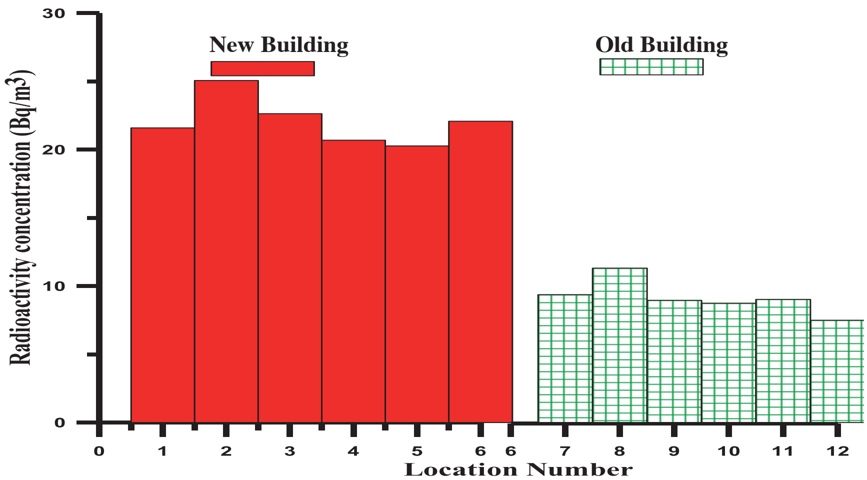

Fig. 3. Outdoor ^{222}Rn radioactivity concentration for new and old buildings.

Figure 4 shows the average indoor and outdoor radioactivity concentrations for new and old tested locations. It is clear that the construction materials used for new structures raise the radioactivity concentrations to values that exceed the US/EPA safe radon concentration limit of 4 pCi/L (1 pCi/L is equal to 37 Bq/m^3). The levels get closer to the 8 pCi/L set by the National Council on Radiation Production and Measurement NCRP (Sherer *et al*., 2013). In contrast to this data, old buildings and their neighborhood have safe radon levels, even though the soil environments are similar locations with new buildings. In addition, these sites are exposed to the same external variables.

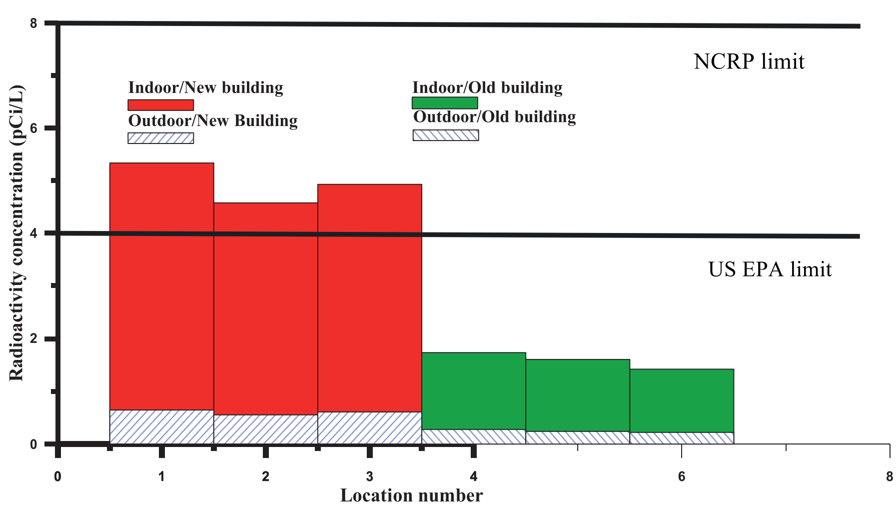

Fig. 4. Average indoor and outdoor radon concentrations for new and old buildings tested in Baghdad.

4. Conclusions

This study investigated the potential radioactivity background influence of almost total usage of cheap, regionally imported construction materials for the construction sector in Iraq, after the 2003 U.S. military invasion. Areas on both side of Baghdad were studies. The indoor and outdoor concentration of radon and radon progeny showed that radioactivity concentrations inside new buildings were about three times higher inside old buildings. Outside new buildings, the radon levels were double those outside new buildings. These results show the vast impact of imported construction materials in surpassing international limits for radon gas concentration. As radon is the second leading cause of lung cancer, inhabitants of these premises are in danger.

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تأثيرات التدهور في صناعة المواد الانشائية على الخلفية الاشعاعية في مدينة بغداد

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الملخص

يُعدّ الاحتواء المحتمل للمواد المشعّة في المواد الانشائية واحداً من أكبر مسببات المخاطر الصحية لساكني وشاغلي مختلف أنواع الأبنية سواء بشكل مباشر أو غير مباشر، من خلال الانتقال عبر الهواء أو في السلسلة الغذائية. لقد شهدت صناعة المواد الانشائية في العراق دماراً هائلاً نتيجة العديد من الصدامات المسلحة الكبرى بدءً من العام 1980 ووصولاً لتاريخنا الحالي، غير أنها اختفت تقريباً بعد العام 2003، مما اضطر قطاع الانشاءات لاستخدام عدد من البدائل الاقليمية الرديئة غالباً والتي لا تمر بفحوصات السيطرة النوعية عبر الحدود.

يهدف البحث لدراسة الموقف الاشعاعي لمناطق سكنية في مدينة بغداد بغرض تقييم سلامة حياة السكان والحيوانات والنباتات من خلال استخدام منظومة مطياف أشعة جاما الموضوعة على مكشاف الجرمانيوم عالي النقاوة GHP. تمت المقارنة بين النماذج المأخوذة من الحيّز الداخلي لعدد من الأبنية في مناطق سكنية تم بناؤها قبل وبعد العام 2003 وكذلك الحال مع نماذج مأخوذة من خارج أبنية تلك المناطق بغرض تكوين صورة واضحة لتأثيرات المواد الانشائية في الخلفية الاشعاعية لتلك المناطق.

بيّنت نتائج الدراسة وصول المحتوى الاشعاعي لغاز الرادون إلى قيمة 200 بيكريل/ م^3 داخل الأبنية الجديدة، مقارنة مع 64.8 بيكريل/ م^3 داخل الأبنية القديمة المنشأة قبل العام 2003، بينما بيّنت نتائج الحيّز الخارجي للأبنية الجديدة احتواءها على 25.05 بيكريل/ م^3 مقارنة مع 11.303 بيكريل/ م^3 للأبنية القديمة.

يعتبر المحتوى الاشعاعي العالي لغاز الرادون داخل الأبنية الجديدة والذي تجاوز المحدد الذي وضعته الوكالة الأميركية لحماية البيئة ومحددات بعض الدول الاوربية، اشارة مهمة لعدم سلامة المواد الانشائية الرخيصة المستوردة بعد العام 2003 نتيجة الدمار الحاصل للصناعة الوطنية. على الرغم من انخفاض القيم الاشعاعية للحيّز الخارجي لكل الأبنية التي تم فحصها عن تلك المأخوذة للحيّز الداخلي، إلا أنها كانت عالية قرب الأبنية الجديدة مقارنة مع نظيراتها قرب الأبنية القديمة.