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Radiological assessment of indoor radon concentrations and gamma dose rates in secondary school buildings in Kuwait



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HIGHLIGHTS

• Indirect approach of measuring radioactivity in building materials.

• Estimation of the radiological parameters.

• Evaluating of the use of building material to satisfy the standard requirements.

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ABSTRACT

The suitability and satisfaction of the use of construction materials for the school buildings in Kuwait regarding the radiological safety was considered. Short-term measurements, of 2 days, were carried out using an active radon monitor that is also equipped with a Geiger-Muller dosimeter to allow simultaneous measurements for both radon concentrations and gamma dose rates, in each location under investigation. Therefore, measurements were carried out in 46 secondary schools in Kuwait, which represents about 30% of the total number of secondary schools in the country. The results show that the indoor radon concentrations varied from 6.04 to 77.9 Bq m⁻³ with a mean of 24.9 Bq m⁻³, and the gamma dose rate values in the range of 65.8–126.5 nSv h⁻¹ with a mean of 100.5 nSv h⁻¹. These radon levels in the schools of Kuwait were similar to the worldwide indoor radon concentration values and well below the indoor action level of radon (200–300 Bq m⁻³) prescribed by many European countries. Similarly, the gamma dose observed in the schools was within the worldwide indoor average value of 14–140 nSv h⁻¹ (from terrestrial sources) for normal background areas.

The results strongly indicate that the construction materials used in the school buildings in Kuwait are within the acceptable levels of radionuclide contents.

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1. Introduction

Buildings play significant roles to humanity. They are built from various types of construction materials which may emit gases and radiation that could, possibly, become dangerous to human lives and health [1].

Generally, human beings are exposed to ionising radiation from various natural and artificial sources, including anthropogenic, cosmogenic and primordial radionuclides as well as radiation generators. Therefore, there is a need to monitor the radioactivity/ radiation levels in air, water, food and other consumer products

* Corresponding author at: College of Technological Studies, Public Authority for Applied Education and Training, P.O. Box 42325, 70654 Shuwaikh, Kuwait. *E-mail address:* ds.alazmi@paaet.edu.kw (D. Al-Azmi). as well as construction materials in order to ensure the safety of the general public who consume and use them.

Construction materials whether of natural origin, artificially made, or by-product contain variable amounts of naturally occurring radionuclides of ⁴⁰K and those in the ²³⁸U and ²³²Th decay chains. The gamma emitters among these radionuclides constitute external exposures of the inhabitants while the alpha emitters, from radon and its decay products, constitute their internal exposures.

1.1. Construction materials and radiation

In the area of civil/construction engineering, construction materials are subjected to many quality insurance tests to check their suitability and satisfy the required standards for the constriction [2]. Some materials are tested to check their suitability as radiation



shields against gamma radiation as with concrete materials [3] or against neutrons in the walls of nuclear reactor centers [4]. With regards to the emission of radiation by materials, this subject represents a major research interest [5], in which measurements of the radionuclide contents in prepared samples are carried out experimentally in certified laboratories to satisfy the recommended safety standards [6–8].

An alternative approach is that, indoor radon concentrations and gamma dose rates in the air of the internal environments are measured practically in the already-constructed buildings [9-11]. This approach may provide a good indication about the radionuclide concentrations that are contained in the materials which are used for the building construction.

1.2. Radiological assessment parameters

Increased levels of indoor radon concentrations in buildings may be attributed partly to the exhalation of radon from the ground underneath and other causes which come from the materials used in the construction as well as accumulation due to confinement [12]. On the other hand, the gamma dose rates are related to the radionuclide continents in the construction materials [13]. Such two radiological parameters; the indoor radon concentrations and gamma dose rates, may be easily measured in the buildings to study, indirectly, the contents of the radionuclide concentrations in the construction material as commonly done as in surveys.

The aim of the present work is to study such two radiological parameters in the secondary school buildings in Kuwait as an indirect approach to evaluate the radionuclide continents in the materials used for the constructions. In this survey, short-term measurements were carried out using an active radon monitor "AlphaGUARD" that is equipped with a Geiger-Muller (GM) dosimeter, allowing simultaneous measurements for both radiological parameters of indoor radon concentrations and gamma dose rates.

2. Secondary schools in Kuwait and their selection

The number of secondary schools in Kuwait is 63 for boys and 73 for girls, a total of 136 secondary schools, at the time of this study and the number is expected to increase. Schools are allocated in six Educational Governorates in Kuwait as follows: Ahmadi, Jahra, Hawalli, Capital, Farwaniya and Mubarak Al-Kabeer.

The official Planning and Information Sector Manual (Ministry of Education) categorizes schools in respect to administrative educational governorates, educational levels, gender and year of construction. Accordingly, the selection of each particular school was performed as follows:

- a. Locations covering the whole geographical vicinity of Kuwait.
- b. Locations covering all the educational governorates.
- c. The selected schools must vary in date of construction.

d. The numbers of schools of both genders are scientifically represented (not less of 30% of total schools).

Thus, three factors were taken into account when selecting secondary schools in each educational governorate; the total number of schools, year of construction, and gender. Accordingly, the selected schools were categorized as follows, Table 1.

3. Materials and methods

3.1. Buildings in Kuwait

All types of buildings in Kuwait including, dwellings and schools, all with different architectural designs, are constructed of solid reinforced concrete structures with cement bricks used for internal walls. The walls are covered with plaster on both sides. Decorative materials such as ceramic tiles as well as marble and granite are commonly used for the floors for hygiene. There are always some concerns for the civil engineers about the use of construction materials with regards to radon exhalation and also the emission of gamma rays, particularly those materials made in large part from concrete, cement and their derivatives [14].

3.2. Investigated schools

The selected secondary schools cover a range of common school buildings constructed in Kuwait over a period of 51 years; oldest school being erected in 1959 and the most modern school was constructed in 2010. The architecture of the schools reveals couple approved designs. The old design comprises of two/three-floor buildings designed in long compartments/corridors taking a "U" shape design around an open courtyard. Each compartment/corridor comprises of 5-6 classrooms with an average of 23 pupils in each classroom and with lavatory facilities containing 3-5 toilet cubicles. While, the new school design comes with a two-floor Beehive-like "octagonal" architectural shape with similar number of classrooms, lavatories and number of pupils of the old school design, Fig. 1. Such a new trend of the Beehive-like design helps to improve the indoor air quality in terms of Air-Conditioning Efficiency and keeps the area out of any dust. All classrooms are with air-conditioning systems; either spilt units in the old buildings or central-type in the new ones. These schools can accommodate between 400 and 750 pupils according to the density of nearby dwellings.

3.3. Radiological measurements

In this survey, a portable radon monitor "AlphaGUARD" (Genitorn Instruments, Germany) was selected for the radiological assessment of the school buildings. The AlphaGUARD is an instrument designed mainly for active measurements of radon concentrations and it is equipped with other metrological sensors for pressure, relative humidity and temperature. Furthermore, it may also be equipped with a Geiger-Muller (GM) dosimeter, as an

Table 1

The number of the secondary schools in Kuwait and the selected percentage for the survey.

Educational Governorate	Ahmadi	Capital	Farwaniya	Hawalli	Jahra	Mubarak Al-Kabeer	Total	Average
Total Schools	29	25	27	21	19	15	136	
Girl-Schools	16	13	15	10	11	8	73	
Boy-Schools	13	12	12	11	8	7	63	
Selected Girl-Schools	5	4	5	3	4	3	24	
Percentage (%)	31.3%	30.8%	33.3%	30%	36.4%	37.5%		33.2%
Selected Boy-Schools	4	4	4	4	3	3	22	
Percentage (%)	30.8%	33.3%	33.3%	36.4%	37.5%	42.9%		35.7%

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