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Background Radiation in the Physics Department, Faculty of Science, University of Kufa

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ABSTRACT

The field of this research was the radiation in the buildings of the Department of Physics, Faculty of Science, University of Kufa using a portable radiation dosimeter. The values of the inner room absorbed dose rate varied from 0.053±0.004 to 0.143±0.008 $\mu Sv/h^{-1}$ with an average 0.097±0.004 $\mu Sv/h^{-1}$, while the outer room absorbed dose rate varied from 0.053±0.005 to 0.110±0.007 $\mu Sv/h^{-1}$ with an average 0.088±0.008 $\mu Sv/h^{-1}$. The average annual effective doses inside and outside rooms were 0.090±0.004 and 0.081±0.008 $\mu Sv/h^{-1}$, respectively, while the cancer risks inside and outside rooms were (0.17±0.008) × 10^{-3} and (0.16±0.001)× 10^{-3}, respectively. All results of the dose rate, annual effective dose and excess lifetime cancer risk in all locations under study were within the allowed limits of 0.274 $\mu Sv/h^{-1}$, 0.48 $\mu Sv/h^{-1}$, and 0.29 × 10^{-3}, so the physics department was safe to work in and did not constitute a danger or hazard to the students, staff and teachers.

Key words: Indoor absorbed dose, portable dosimeter, University of Kufa. occurring

INTRODUCTION

Materials are continuously emitting ionizing radiations due to the NORM in the surroundings, populations and the cosmic outer space radiation that continues to bombard the earth which is called background radiation (Ahmed *et al.*, 2019). Furthermore, additional exposure to ionizing radiation comes from anthropogenic activities such as producing medical x-rays, trying to generate nuclear power, running tests on nuclear weapons and manufacturing irradiated smoke alarms. The radiation sources can be classified as natural sources from outer space containing highly charged particles such as electrons, positrons and other subatomic particles; radioactive substances represented by decay chains in the earth's crust and core ranging from 1 to over 10 mSv and relying on people living who have no protection against exposure to them (Ibrahim *et al.*, 2021); and finally, internal dose sources from the presence of ^{40}K in all-natural potassium and the high content of potassium in human tissue (Ibrahim *et al.*, 2021). Man-made (industrial) radiation includes nuclear medicine, x-rays in diagnostics and radiotherapy. NORM is the origin of exposure to the world's population of up to 85% of the typical human annual dose, and the rest is from industrial sources relying on the people's lifestyle (Salman *et al.*, 2019; Yang and Sun, 2022). Natural radioactivity can be found in rocks, soils and building materials, as well as in water and air, so no place on earth is immune to it.The most common forms of radiation are the alpha and beta particles, electromagnetic radiation, and neutrons (Tsoulfanidis and Landsberger, 2015). Radon (the radioactive gas) emitted from the radio-nuclides contained in buildings causes an increase in radiation dose rate exposure; nevertheless, this rate alters according to the lifestyle and living requirements of people. In homes, schools, and buildings where people like professors, teachers, and students spend a long time, it is important to measure the risk of background radiation levels (Thomas *et al.*, 2022). This contributes to the world's population's exposure due to the consideration that the largest source of them is nature, moreover the human operations. As a result, the purpose of this research was to measure the indoor radiation absorbed dose rates as background radiation in the air of buildings at the Physics Department location, Faculty of Science, University of Kufa.

MATERIALS AND METHODS

Najaf Governorate is one of the most prominent governorates in Iraq. It is situated to the south-west of the Iraqi capital, Baghdad. It is considered the fifth-largest city in terms of population and also one of Iraq's most substantial religious cities. Its history dates back to the pre-Islamic era, when it was a center for Christian monasteries; later, it became the capital of the Islamic state. The University of Kufa, one of the Iraqi universities located in the middle of the region of Najaf, includes many faculties and residential buildings for its professors and staff. The examination was conducted at 30 sites in the faculty of science at the University of Kufa, especially in the Department of Physics, to determine the presence of radiation in them, using an alert dose test device, which is made in the United States of America.

The Investigator of Radioactivity Alerts EXP, a handheld microprocessor detector, has the potential to detect harmful ionizing radiation [alpha (α), beta (β), gamma (ϒ), and x-ray]. It has an LCD (liquid crystal display) with four digital numbers calculating each millirem per hour (mR/h), and indicators of functions (Alasadi and Al-Hamidawi, 2022). The automatic operational ranges for this detector are able to detect the low ionizing levels of the major ionization types of radiation, which are the particles of alpha and beta and the rays of gamma and x-ray. The Geiger-Müller (GM) tube, which has two of the quenched halogens, is uncompensated, and an end window of a narrow mica detects radiation that is ionizing. The radiation sign that was placed on the frontal label of the detector referred to its center. It was previously used to survey NORM contamination, perform gross wipe counting, inspect people, packages and equipment, conduct regulatory reviews, and detect low-energy radio-nuclides. The utility menu on the back of the detector has a response time of 3 sec to switch from count per minute (CPM) to count per second (CPS) and from mR/h to mSv/h. This item resets the calibration factor to 100, regulates the calibration and performs a factory reset to the main settings. It has an

Table 1. The information about the sites in the current study

S. No.	Name of site	Sample	No. of	Location
1.	Department chair	P1	First	Inside room
2.	Department secretariat	P2	First	Inside room
3.	Deputy department chair	P3	First	Inside room
4.	Examination Committee/Postgraduate	P4	First	Inside room
5.	Examination Committee/ Undergraduate	P5	First	Inside room
6.	Computer lab	P6	First	Inside room
7.	Classrooms	P7	First	Inside room
8.	Classrooms	P8	First	Inside room
9.	Teacher classrooms	P9	First	Inside room
10.	Teacher classrooms	P10	First	Inside room
11.	Classrooms	P11	First	Inside room
12.	Classrooms	P12	First	Inside room
13.	Classrooms	P13	First	Inside room
14.	Teacher classrooms	P14	First	Inside room
15.	Teacher classrooms	P15	First	Inside room
16.	Electricity Lab	P16	First	Inside room
17.	Modern laboratory	P17	First	Inside room
18.	Thermal laboratory	P18	First	Inside room
19.	Analogue Lab	P19	First	Inside room
20.	Solid Lab/Postgraduate	P20	Ground	Inside room
21.	Side-rooms of solid lab	P21	Ground	Inside room
22.	Laser lab	P22	Ground	Inside room
23.	Mechanic lab	P23	Ground	Inside room
24.	Nuclear Lab	P24	Ground	Inside room
25.	Building of department chair	P25	First	Outside room
26.	Building labs (nuclear and mechanics)	P26	Ground	Outside room
27.	Building labs (Laser and solid)	P27	Ground	Outside room
28.	Building labs (Electricity and modern)	P28	First	Outside room
29.	Building labs (thermal and analogue)	P29	First	Outside room
30.	Building of classroom	P30	First	Outside room

audio indicator as well as an internal beeper that can be turned off to operate silently, and it is powered by a 9-volt alkaline battery.

Thirty sites from various locations in the Physics Department of the Faculty of Science at the University of Kufa were measured. Sites were divided into two categories: inside rooms and outside rooms (Table 1), which included the site's name, sample code, floor number and location.

In the current study, background radiation in the air at one meter from the earth's surface (inside and outside rooms) was measured using a portable dosimeter (Alert Inspector International, Inc., USA). The device was calibrated with a value of 3340 (mR^{-1}/h) using the Company of Man Faction (CPM). At each site, five locations were measured for dose rate in units of μSv/h; at any site, the time measured was 10 min, as shown directly on the LCD digital display. Then, by applying the standard deviation for all sites, the average values were calculated.

The occupancy factor (OF) influenced the AED in units of mSv per year. For nearly all students, staff and teachers in the Department of Physics, Faculty of Science at the University of Kufa, the respective equation to determine the OF was:

$$30 \frac{\text{hour}}{\text{week}} \times 43 \frac{\text{weed}}{\text{year}} = 1290 \frac{\text{hour}}{\text{year}} \quad \ldots(1)$$

The OF for the department was 1290/8760 ≈ 15%.

As a result, the AED equation used the following relationship (Kobeissi *et al.,* 2014; Ramli *et al.,* 2014):

$$\text{AED} \left(\frac{\text{mSv}}{\text{y}}\right) = D_{indoor} \times T \times Cc \times OF_{indoor} \quad \ldots(2)$$

Where, D_{indoor} indicated the dose rate in units of $\mu Sv/h^{-1}$, T was for the time, which was equal to 8760 h per year, and C_C, was equal to 0.7, for the correction coefficient factor.

The respective formula to calculate the Excess Lifetime Cancer Risk (ELCR) was (Abojassim, 2021):

$$\text{ELCR} = \text{AED} \times \text{DL} \times \text{RF} \quad \ldots(3)$$

Where, DL denoted the average lifespan of spending time at university, which was equal to 40 years, and RF was the risk factor equal to 0.05 Sv^{-1} (ICRP) (Dhahir *et al.,* 2019).

RESULTS AND DISCUSSION

The results of background (alpha, beta, gamma and x rays) at different sites inside and outside buildings were measured using a portable dosimeter (inspector EXP), The values of D_{indoor} in the air of the inside rooms with standard deviation (S.D.) in units of $\mu Sv/h^{-1}$ varied from 0.053±0.004 to 0.143±0.008, while those of the outside rooms varied from 0.053±0.005 to 0.110±0.007 (Table 2). Similarly, the values of AED inside rooms due to the indoor dose rate in units of mSv/y varied from 0.049 to 0.132, while those of the outside rooms varied from 0.049 to 0.101. The variation of values of ELCR for inside and outside rooms was (0.10- 0.26) $\times 10^{-3}$ and (0.10-0.20) $\times 10^{-3}$, respectively. The average values of D_{indooe}, AED, and ELCR for all sites of inside rooms were 0.097±0.004 μSv/h, 0.090±0.004 μSv/h, and (0.17±0.008) $\times 10^{-3}$, respectively. Similarly, the average values of D_{indooe}, AED and ELCR for all sites of outside rooms were 0.088±0.008 μSv/h, 0.081±0.008 mSv/h^{1}, and (0.16±0.001) $\times 10^{-3}$, respectively. It was found that variations in the background radiation data in the current investigation can be attributed to the difference in ventilation from one place to another, as well as on the nature of the people in those buildings.

According to the UNSCEAR (UNSCEAR, 2020) report, the D_{indoor} rates (Fig. 1) determined for air buildings of the physics department in this study were lower than the international (0.274 μSv/h). Furthermore, according to the UNSCEAR report (UNSCEAR, 2020), all AED results (Fig. 2) for all sites under study were lower than the international standard (0.48 mSv/h). The ELCR data (Fig. 3) in this study were within the permissible range of (0.29×10^{-3}) reported in a previous study (Haghparast *et al.*, 2020). The average value of D_{indoor} for inside rooms was higher than that for outside rooms, owing to the higher ventilation in outside rooms (Fig. 4). Similarly, the average value of D_{indoor} for the ground floor was higher than the first floor (Fig. 5). It was due to the larger contribution of background radiation from the soil on the ground floor than on the

Table 2. Dindoor (μSv/h), AED (mSv/y) and ELCR at the studied locations

S. No.	Sample code	Dindooe (μSv/h)		AED (mSv/y)	ELCR × 10^{-3}
		Average	S. D.		
1.	P1	0.131	0.007	0.120	0.24
2.	P2	0.089	0.006	0.082	0.16
3.	P3	0.119	0.007	0.109	0.22
4.	P4	0.117	0.007	0.108	0.22
5.	P5	0.113	0.007	0.104	0.21
6.	P6	0.107	0.006	0.098	0.20
7.	P7	0.053	0.004	0.049	0.10
8.	P8	0.065	0.005	0.060	0.12
9.	P9	0.119	0.007	0.109	0.22
10.	P10	0.113	0.007	0.104	0.21
11.	P11	0.077	0.005	0.071	0.14
12.	P12	0.083	0.006	0.076	0.15
13.	P13	0.143	0.008	0.132	0.26
14.	P14	0.071	0.005	0.065	0.13
15.	P15	0.101	0.006	0.093	0.19
16.	P16	0.083	0.006	0.076	0.15
17.	P17	0.071	0.005	0.065	0.13
18.	P18	0.077	0.006	0.071	0.14
19.	P19	0.107	0.007	0.098	0.20
20.	P20	0.083	0.006	0.076	0.15
21.	P21	0.107	0.007	0.098	0.20
22.	P22	0.089	0.006	0.082	0.16
23.	P23	0.113	0.007	0.104	0.21
24.	P24	0.089	0.006	0.082	0.16
25.	P25	0.110	0.007	0.101	0.20
26.	P26	0.101	0.006	0.093	0.19
27.	P27	0.107	0.007	0.098	0.20
28.	P28	0.065	0.005	0.060	0.12
29.	P29	0.053	0.005	0.049	0.10
30.	P30	0.095	0.006	0.087	0.17
Average ± S.D inside	0.097±0.004	0.090±0.004	0.17±0.008		
Average ± S.D outside	0.088±0.008	0.081±0.008	0.16±0.001		
International limit	0.274 (UNSCEAR, 2019)	0.48 (UNSCEAR, 2019)	0.29 (Haghparast *et al.*, 2020)		

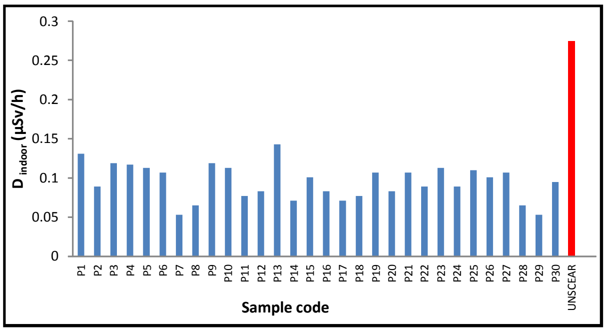

Fig. 1. Comparison of D_{indoor} results in the present study with the UNSCEAR safety limit.

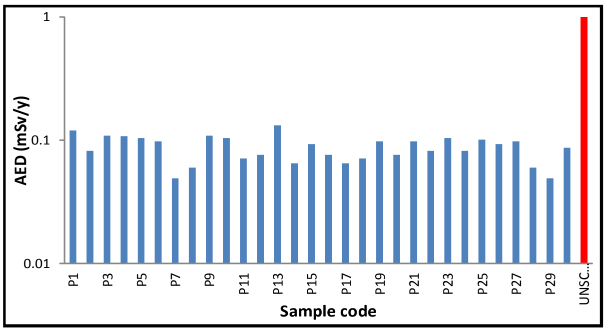

Fig. 2. The AED results in the current study in comparison with the UNSCEAR safety limit.

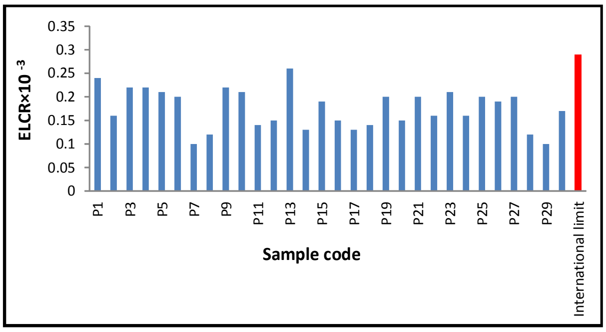

Fig. 3. ELCR results in the current study compared to the international limit.

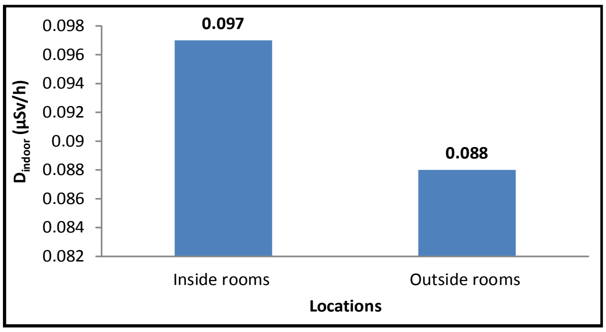

Fig. 4. D_{indoor}, AED and ELCR comparison results between inside and outside rooms.

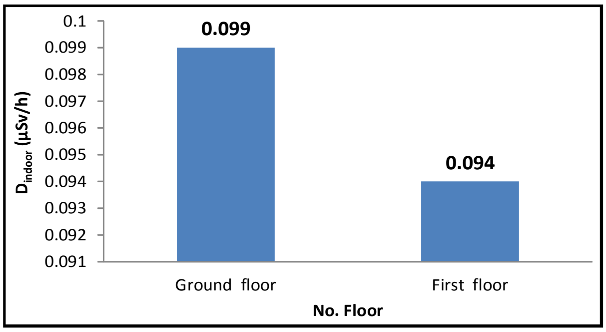

Fig. 5. Dindoor comparison results for the ground and first floors.

first floor, entering the ground floor from the ground (Senitkova and Kraus, 2019). The currently investigated average value of the absorbed dose with that of the Iraqi and foreign studies showed that the indoor background radiation in the workplace was the lowest (Table 3). Finally, background radiation levels measured in the current study area were within the international limit and posed no post-exposure risk to all humans who worked there.

Table 3. Comparison of the investigated current study with other studies

D_{indoor} (µSv/h)	Study areas	Ref.
0.061	Iraq (Najaf)	Dosh *et al.* (2022)
0.95	Iraq (Kufa)	Alasadi *et al.* (2016)
0.14	Iraq (Wasit)	Jaber *et al.* (2020)
0.135	Iran (Hamadan)	Samadi *et al.* (2020)
0.136	Nigeria (Okoye and Avwiri)	Chukwuemeka and Gregory (2013)
0.097	Current workplace (Iraq)	

CONCLUSION

The results of the dose rate due to background obtained in this study inside and outside the rooms of the Physics Department in the Faculty of Science at the University of Kufa using the transportable device inspector EXP were observed within or below the safety limit of UNSCEAR (0.274 µSv/h). Furthermore, the results of the annual effective dose in all study sites were within the UNSCEAR recommended global limit (0.48 mSv/h). The excess lifetime cancer risk due to the rate of the indoor dose was calculated and found to be less than the international limit of (029 × 10^{-3}). It was found that the average indoor dose rate for inside rooms was larger than that of outside rooms due to the lower level of ventilation, as well as that the average indoor dose rate for the ground floor was larger than the first one because of the natural and random gases from the terrestrial chain. Finally, it was concluded that the research study area was free of the health risks associated with background radiation.

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