Iranian Journal of Medical Physics

ijmp.mums.ac.ir

The Impact of Low-level Exposure to Radiation in Natural Ecosystems of Najaf and Dhi Qar Cities, Iraq

Basim Almayahi*, Hakeem J. I., Laith Saheb

Department of Environment, Faculty of Science, University of Kufa, 54003 Kufa, Najaf Governorate, Iraq

ARTICLE INFO

Article type:
Original Article

Article history:
Received: Jun 25, 2017
Accepted: Sep 07, 2017

Keywords:
Background Radiation
Environment
Gamma Ray
Public Health

ABSTRACT

Introduction: This study investigated the exposure rates of background radiations in selected locations of Najaf and Dhi Qar cities, Iraq.
Materials and Methods: Exposure rates were quantified using a portable Geiger–Müller meter. Frequent readings of gamma dose rates were recorded (82 and 101 nGy h^{-1}).
Results: The lowest absorbed dose rate was found to be 43.5±17.4 $nGyh^{-1}$ in Najaf (outdoor environments), and the highest was 174±8.7 nGy h^{-1} in Dhi Qar city (outdoor environments). Overall, the absorbed dose rates of background radiation fell within the worldwide range reported in other regions.
Conclusion: The selected locations in Najaf and Dhi Qar cities showed normal absorbed dose rates with no adverse biological effects on people in the studied areas.

► *Please cite this article as:*
Almayahi BA, Hakeem JI, Saheb L. The Impact of Low-level Exposure to Radiation in Natural Ecosystems of Najaf and Dhi Qar Cities, Iraq. Iran J Med Phys 2018; 15: 1-5. 10.22038/ijmp.2017.24540.1245.

Introduction

The levels of natural background gamma radiation differ from site to site due to underlying rock formations and soil compositions. This is the result of different concentrations of radionuclides created by cosmic radiation in the soil. Cosmic ray increases with increasing altitude. The people living at high altitudes suffer from ray more than at sea level. The ray intensity varies with latitude, because of the Earth's magnetic field. Since the formation of Earth, radiations have existed in our environment [1]. Life has always included a significant level of radiations emanating from space, the Earth, and our bodies. Brick and stone houses have higher radiation levels than wooden ones [2]. Natural radiation that is called background radiation exists everywhere and varies from one site to another. For instance, Colorado area has more cosmic and terrestrial (naturally occurring uranium) radiations than the east and west coasts of the USA. Therefore, people living in this state are exposed to higher doses of background radiation compared to coastal residents [2]. US residents receive an annual natural radiation dose of 3.1 mSv. Natural and human-made radiations originate from different sources; however, they have similar effects.

Annually, human-made radiations emanating from medical, industrial, and commercial activities contribute an effective dose of 3.1 mSv [2]. The data concerning radiation and cancer is based on populations receiving high exposure rates. The highest worldwide exposure rates were reported in Iran (450 mSv y^{-1}) and Brazil (120 mSv y^{-1}) [3]. The soil types and geological and geographical conditions influence terrestrial gamma dose rates emanated from naturally occurring radionuclides [4, 5]. The literature on environmental terrestrial gamma radiation indicates that further studies addressing the natural gamma dose rates in the areas under investigation, comparing the dose rates in these areas, and evaluating the statistical differences are needed in Iraq [6-10].

Considering the lack of studies on background radiation in Iraq, we carried out this survey in Najaf and Dhi Qar, Iraq, to measure the background radiation.

Materials and Methods

Najaf is located in Najaf Governorate in Iraq. The coordinates for this administrative division are 31.3517° N, 44.0960° E. Dhi Qar Governorate is established in southern Iraq and Nasiriyah is its

*Corresponding Author: Department of Environment, Faculty of Science, University of Kufa, 54003 Kufa, Najaf Governorate, Iraq. E-mail: basimnajaf@yahoo.com; basim.almayahi@uokufa.edu.iq; Tel: 009647823004353

capital city with 31.1042° N, 46.3625° E coordinates. The University of Kufa in Najaf was found in 1987 and includes 21 faculties. The Faculty of Medicine at the University of Kufa was established in 1977 as a part of Al Mustansyriya University. The College of Arts was established in 1989 with only two departments of Arabic Language and History. Figure 1 exhibits the areas under study.

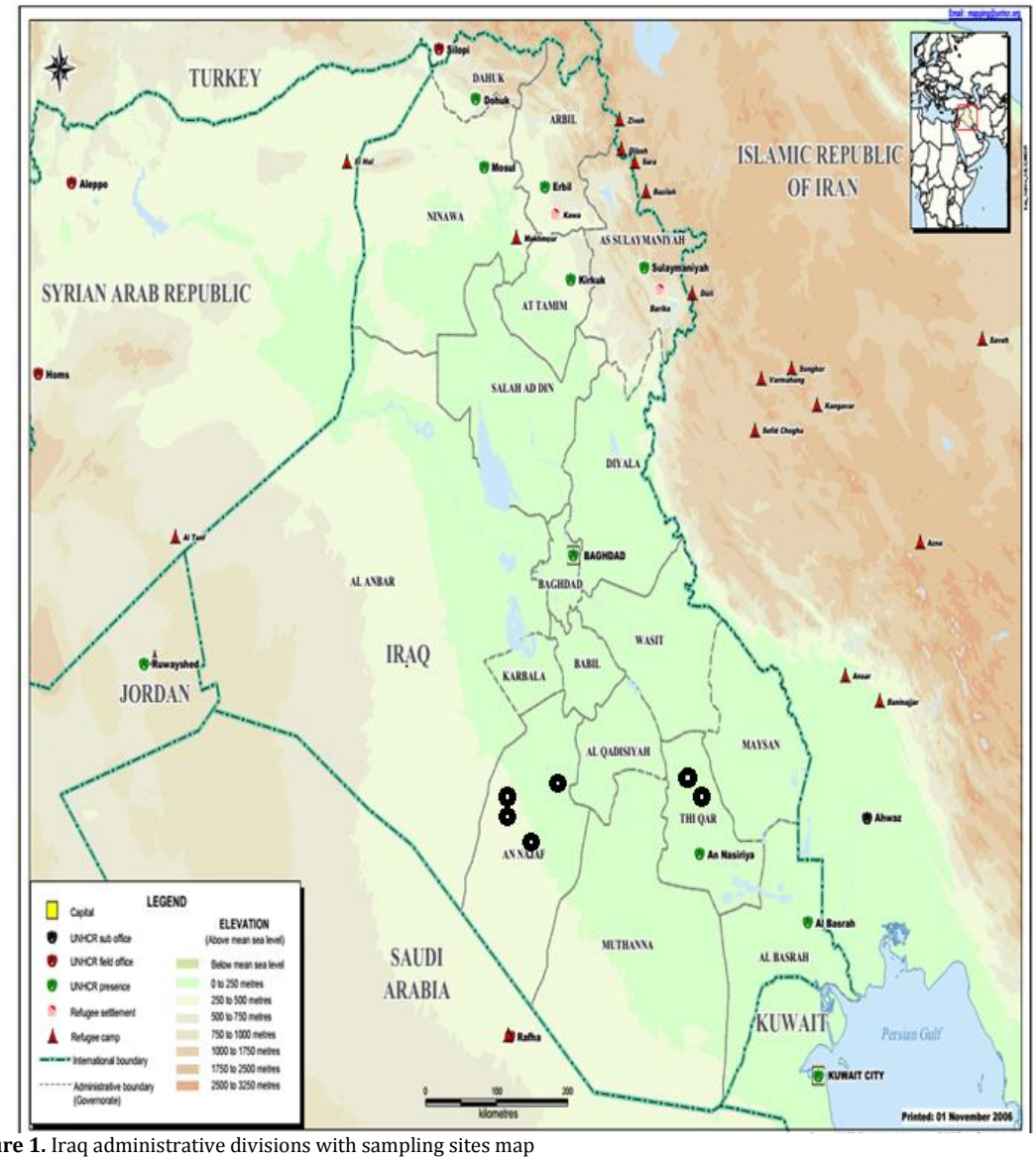

Figure 1. Iraq administrative divisions with sampling sites map

The background radiation of 50 locations in Najaf city (some buildings [8 locations], College of Science in Kufa University [9 locations], College of Agriculture in Kufa University [4 locations], Al-Mishikhab [2 locations]), and Dhi Qar city [Al-Naser District: 20 locations and Al-Shtrah District: 7 locations]) with different distances from each other were investigated from 2013 to 2014. The results were obtained using Geiger–Müller (GM) meter - Exp Digital Radiation Monitor (Cole-Parmer Scientific Experts, United States).

In order to calibrate the survey meter, cesium-137 (^{137}Cs; 6.01 μCi) and cobalt-60 (^{60}Co, 0.23 μCi) sources were used in 2012. The exposure rate of ^{137}Cs was higher than that of ^{60}Co, which was due to the fact that ^{137}Cs source has a higher activity level. The total gamma radiation doses (mR h^{-1}) from soil and indoor environments were measured for 5 min with three readings per site 1 m above ground level [11, 12]. To analyze the data, One-way ANOVA was run using SPSS, version 20.0.

Results

We obtained 150 gamma dose rate readings using SEI Inspector EXP. The readings are presented in Table 1.

Table 1. Gamma dose rates recorded *in situ* 1 m above the sampling sites level using SEI Inspector EXP

SC*	Location	Gamma dose rates (nGy h^{-1})			Dose equivalent (μSv h^{-1})
		Min.	Max.	Mean±SD	Mean
L1	Najaf	43.5	104.4	69.6±31.4	0.0696
L2	Najaf	52.2	69.6	63.8±10.0	0.0638
L3	Najaf	87.0	121.8	101.5±18.1	0.1015
L4	Najaf	69.6	121.8	92.8±26.6	0.0928
L5	Najaf	34.8	87	69.6±30.1	0.0696
L6	Najaf	95.7	104.4	98.6±5.0	0.0986
L7	Najaf	60.9	69.6	66.7±5.0	0.0667
L8	Najaf	69.6	121.8	92.8±26.6	0.0928
L9	Najaf	95.7	113.1	104.4±8.7	0.1044
L10	Najaf	60.9	156.6	92.8±55.3	0.0928
L11	Najaf	87.0	104.4	98.6±10.0	0.0986
L12	Najaf	60.9	139.2	98.6±39.2	0.0986
Average	Indoor Environments			87.5±22.2	
L13	Najaf	52.2	104.4	72.5±28.0	0.0725
L14	Najaf	43.5	95.7	69.6±26.1	0.0696
L15	Najaf	60.9	43.5	43.5±17.4	0.0435
L16	Najaf	87.0	113.1	87.0±26.1	0.087
L17	Najaf	121.8	147.9	130.5±15.1	0.1305
L18	Najaf	95.7	113.1	104.4±8.7	0.1044
L19	Najaf	69.6	139.2	101.5±35.2	0.1015
L20	Najaf	113.1	139.2	124.7±13.3	0.1247
L21	Najaf	87.0	95.7	89.9±5.0	0.0899
L49	Najaf	60.9	78.3	72.5±10.0	0.0725
L50	Najaf	87.0	104.4	95.7±8.7	0.0957
Average	Outdoor Environments			90.2±17.6	
L22	Dhi Qar	87.0	113.1	98.6±13.3	0.0986
L23	Dhi Qar	87.0	121.8	98.6±20.1	0.0986
L24	Dhi Qar	60.9	87.0	78.3±15.1	0.0783
L25	Dhi Qar	113.1	121.8	116±5.0	0.116
L26	Dhi Qar	95.7	130.5	116±18.1	0.116
L27	Dhi Qar	87.0	87.0	87.0±0.0	0.087
L28	Dhi Qar	87.0	104.4	95.7±8.7	0.0957
L29	Dhi Qar	165.3	182.7	174±8.7	0.174
L30	Dhi Qar	87.0	104.4	95.7±8.7	0.0957
L31	Dhi Qar	60.9	95.7	81.2±18.1	0.0812
L32	Dhi Qar	95.7	130.5	110.2±18.1	0.1102
L33	Dhi Qar	113.1	147.9	118.9±26.6	0.1189
L34	Dhi Qar	113.1	78.3	92.8±18.1	0.0928
L35	Dhi Qar	87.0	121.8	107.3±18.1	0.1073
L36	Dhi Qar	87.0	87.0	87.0±0.0	0.087
L37	Dhi Qar	87.0	104.4	92.8±10.0	0.0928
L38	Dhi Qar	95.7	121.8	107.3±13.3	0.1073
L39	Dhi Qar	87.0	113.1	101.5±13.3	0.1015
L40	Dhi Qar	60.9	69.6	63.8±5.0	0.0638
Average	Outdoor Environments			101.2±13.1	
L41	Dhi Qar	69.6	121.8	95.7±26.1	0.0957
L42	Dhi Qar	87.0	121.8	101.5±18.1	0.1015
L43	Dhi Qar	87.0	121.8	101.5±18.1	0.1015
L44	Dhi Qar	69.6	121.8	89.9±28.0	0.0899
L45	Dhi Qar	95.7	113.1	104.4±8.7	0.1044
L46	Dhi Qar	87.0	139.2	104.4±30.1	0.1044
L47	Dhi Qar	78.3	95.7	87.0±8.7	0.087
L48	Dhi Qar	78.3	95.7	60.9±46.0	0.0609
Average	Indoor Environment			93.2±23.0	
Min.				43.5	0.044
Max.				174	0.174
Avg.				94.19± 2.50 (SE)	0.094±0.003 (SE)

*SC (Site Code), SD (Standard Deviation), SE (Standard Errors)

The gamma dose rates in the sites under study ranged from 43.5±17.4 to 174±8.7 nGy h^{-1}. The highest mean dose rate was 104.4±8.7 nGy h^{-1} in Najaf city (L9, indoor environments). The dose rates in this city ranged from 43.5 to 130.5 nGy h^{-1} (outdoor environments) and from 63.8 to 104.4 nGy h^{-1} (indoor environments). The lowest mean dose rate was observed in Dhi Qar city (indoor environments) at 60.9±46.0 nGy h^{-1}. The dose rates in this city ranged from 63.8 to 174 nGy h^{-1} (outdoor environments) and from 60.9 to 104.4 nGy h^{-1} (indoor environments).

Table 2 displays no significant differences between the absorbed gamma dose rates obtained in Najaf and Dhi Qar cities (indoor environments).

Table 2. Analysis of variance for absorbed gamma dose rates (nGy h^{-1}) in Najaf and Dhi Qar

	Sum of squares	Degrees of freedom	Mean square	F ratio	Sig.
Inter-group	0.0522	1	0.0522	5876.9979	0.4145
Intra-group	4.5849	58	0.0783		
Total	4.6371	59			

Table 3. Analysis of variance results for absorbed gamma dose rates (nGy h^{-1}) in Najaf and Dhi Qar cities

	Sum of squares	Degrees of freedom	Mean square	F ratio	Sig.
Inter-group	0.2958	1	0.2958	30811.5198	0.0632
Intra-group	7.2645	88	0.0783		
Total	7.5603	89			

Table 4. The gamma dose rates of the studied areas were compared with the dose rates reported from other regions of Iraq and the world

Location	Gamma dose rates (nGy h^{-1})
Germany [13]	91
Italy [13]	72
Switzerland [13]	74
Ireland [14]	82
Kufa University (Colleges of science and agriculture) [6]	67
Kufa University [8]	99
Malaysia [15]	92
China [15]	62
India [16]	117
Japan [15]	53
United States [15]	47
Egypt [15]	22
Greece [15]	56
Portugal [15]	84
Russia [15]	65
Spain [15]	76
Iran [17]	113
Turkey [18]	253
Nigeria [19]	153
World [5]	59
Present Study	94.19± 2.50

Table 3 demonstrates no significant differences between absorbed gamma dose rates in Najaf and Dhi Qar cities (outdoor environments).

Table 4 summarizes the natural absorbed gamma dose rates obtained from various regions worldwide.

Discussion

The frequently recorded *in situ* readings in this study were found to be between 82 and 101 nGy h^{-1}. The mean dose rate in Dhi Qar was 94± 2.95 nGy h^{-1}, and the highest mean dose rate was found to be 174 nGy h^{-1} city, which is three times higher than the world average (59 nGy h^{-1}). The lowest mean dose rate was reported to be 44 nGy h^{-1} in Najaf, which is lower than the world average. The dose rates obtained in the present study were consistent with the ones obtained in Germany and Malaysia [13, 18]. The exposure rates from other parts of the world such as Babylon and Kufa universities, India, Iran, Turkey,

and Nigeria were higher than those found in Najaf and Dhi Qar cities [8, 16-19]. The results obtained from other countries were lower than the findings of the current study, as shown in Table 4.

The equivalent doses were 0.044 and 0.174 μSv h^{-1} in Najaf and Dhi Qar, respectively. All the absorbed dose rates quantified in the indoor environments of Dhi Qar city (93.2±23.0 $nGyh^{-1}$) were higher than the dose rates found in Najaf city (87.5±22.2 $nGyh^{-1}$). However, these differences were not significant. All the dose rates measured in the outdoor environments of Dhi Qar city (mean: 101.2±13.1 $nGyh^{-1}$) were insignificantly higher than the rates measured in Najaf city (mean: 90.2±17.6 $nGyh^{-1}$). Najaf and Dhi Qar cities could be classified as areas with normal background radiation.

Conclusion

We found no significant differences between the absorbed doses rates recorded in Dhi Qar and Najaf cities. Overall, the background radiation levels of the locations under study were low and had no adverse effects on human health. This study is beneficial for radiological protection and prevention from extreme exposure of the population living in the studied areas. It is concluded that gamma absorbed dose rates were low, and in comparison with the results of other studies performed worldwide, had no negative impacts on the public health.

Acknowledgement

We would like to thank the University of Kufa for the financial support.

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