Mapping of background radiation for soil samples in Kufa Districts, Iraq

Lubna A. Alasadi and
Ali Abid Abojassim*

Department of Physics,
Faculty of Science,
University of Kufa,
Al-Najaf, Kufa, Iraq
Email: lubna.alasadi@uokufa.edu.iq
Email: ali.alhameedawi@uokufa.edu.iq
*Corresponding author

Abstract: The study of background radiation is significant for human health. So, the present study was focused on Dose rate (D), Annual Average Effective Dose (AAED) and Excess Lifetime Cancer Risk (ELCR) due to the natural background in soil samples at different sites in Kufa districts at Al-Najaf governorate. All measurement was using portable radiation dosimeter type Inspector Exp. made in the USA. GIS technical also was used for mapping of radiation in all results of background. The average values of D, AAED and ELCR were 0.127±0.005 μSv/h, 1.12±0.04 mSv/y and (3.90±0.15) $\times 10^{-3}$, respectively. The highest values of D and AAED were 0.203±0.020 μSv/hr, and 1.78 mSv/y in Alshorta districts which were lower than the average of worldwide limits of 0.247 μSv/hr and 2.4 mSv/y, respectively. Therefore, results concluded that the risk of background radiation in soil samples in the present study to human health is minimal.

Keywords: background radiation; dose rate; annual effective dose; cancer risk; radiation dosimeter; Kufa districts.

Reference to this paper should be made as follows: Alasadi, L.A. and Abojassim, A.A. (2021) 'Mapping of background radiation for soil samples in Kufa Districts, Iraq', *Int. J. Nuclear Energy Science and Technology*, Vol. 15, No. 1, pp.79–91.

Biographical notes: Lubna A. Alasadi, PhD, is employed in University of Kufa, Faculty of Science, Department of Physics from 2006 (BSc in 2004, MSc in 2011). She is an Assistant Professor in Physics Department until present, and PhD student at Faculty of Education for Girls.

Ali Abid Abojassim received BSc degree in Physics from University of Kufa, Collage Science Department of Physics in 2003, MSc degree in Nuclear Physics from University of Babylon, College Science Department of Physics in 2006 and PhD degree in Nuclear Physics and Environmental from Baghdad College Science Department of Physics in 2013. He worked in University of Kufa, College Science Department of Physics from 2006 up to now.

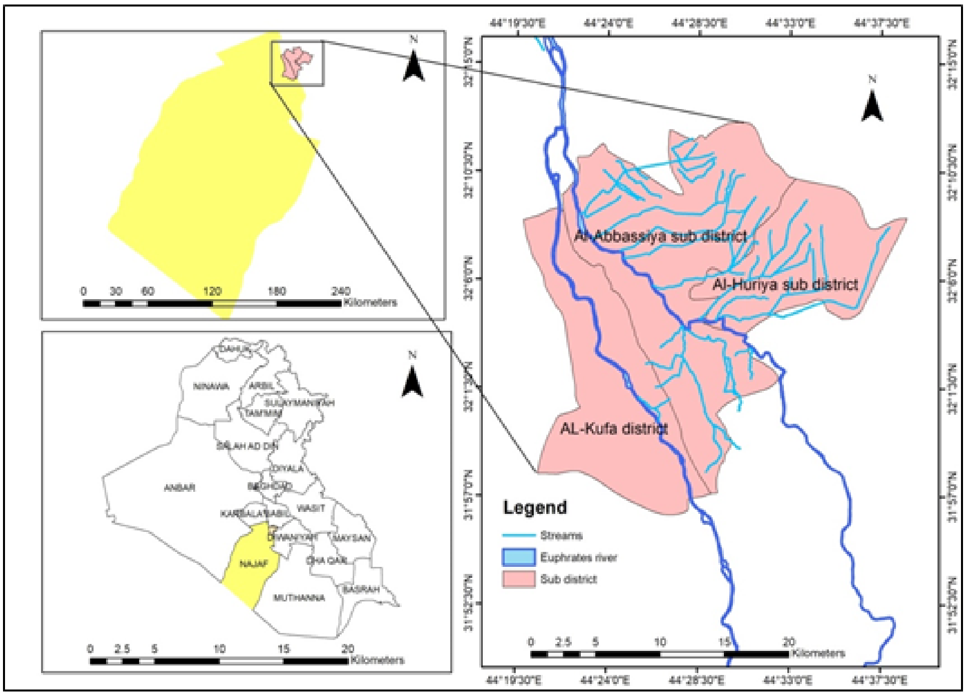
1 Introduction

There are three primary sources of natural background radiation (cosmic radiation, radiation from terrestrial sources and radioactivity in the body). Other sources of human exposure exist, some of which are unique to the previous few decades. Diagnostic and therapeutic radiology, isotopes in medicine, radioactive waste, the fallout from nuclear weapon tests and occupational exposure to nuclear accelerator reactors are all examples of these sources (Harrison, 2001). Background radiation which is radiation emitted by radioisotopes that exist on or inside the Earth, in the air we breathe, in the water we drink, in the food we eat and in our bodies, as well as radiation incident upon the Earth from outer space, cosmic rays (Attix and Tochilin, 2016). The origin of background radiation in the Earth's crust stems directly from nuclear series such as uranium-238, uranium-235 and thorium-232. The decay of practices is distributed for minutes in the ground soil within a few metres of the Earth's surface. Non-ionising (microwaves, visible light, radio waves, T.V. waves and ultraviolet light) and ionising (microwaves, visible light, radio waves, T.V. waves and ultraviolet light) radiations are the two primary forms of radiation: X-rays, neutrons and (and) particles (Beyzadeoglu et al., 2010). Natural materials such as soil, sand, cement, rock, etc., which contain amounts of natural radioactivity of ^{238}U, ^{226}Ra and ^{40}K, were used as building materials for building buildings and houses. Ionisation radiation may be released from the ground, rocks, and building materials, and accumulate, with its short-lived progeny in the atmosphere inside the residences (Hendry et al., 2009). The global average effective dose per person is about (2.4) mSv and ranges from about (1 to more than 10) mSv depending on where people live (UNSCEAR, 2010). Energy travels from ionising radiation to the living organism's body and leads to the ionisation of the atoms of the cells. Whether ionising radiation comes from a source outside the body or from contamination of the body from the inside with radioactive materials leads to biological effects in the body that can later appear as clinical symptoms (Hendry et al., 2009). Ionising radiations cause many damages to human health. Many of these damages are fatal or harmful to make a person suffer from their effects throughout his life (UNSCEAR, 2010). Soil is considered an essential primary resource to life and food production – the existence of natural radioactivity in soil results from inside and outside exposure to humans (Attix and Tochilin, 2016). Environmental background radiation mentoring programmer plays a vital role in assuring the safety and security of society. That is why it is essential to know the increase in radiation levels due to its impact in many aspects. Most noticeably, those connected with genetic and health-related impact and body negativity. A GIS capacity as spatial information handling and examinations instruments accessible can deal with a broad scope of data. GIS gives a coordinated registering condition to social and natural information incorporation. Frameworks combined with GIS provide an effective structure for putting away, recovering spatial information, mapping information and last outcomes (Hussein et al., 2020). There are many previous studies on measuring background radiation in different areas in Iraq and other countries (Khader, 2010; Emelue, 2020; Okoye and Avwiri, 2013; Hosoda et al., 2021). The present research maps the background radiation for soil samples in Kufa districts measured using a portable dosimeter. Maps drowned by GIS technology for Dose rate (D), Annual Average Effective Dose (AAED), and Excess Lifetime Cancer Risk (ELCR).

2 Area of study

Al-Najaf governorate is located in the South West Region of Iraq, which is represented by a latitude (29°50'00" N–32°21'00" N) and by a longitude (42°50'00" E–45o44'00" E) covering an area of (11281153.88). From the north, it is restricted by Babel and Karbala provinces. From the east, it's bounded by Qadsia and Muthna provinces from the south and southwest by Saudi Arabia (Sissakian and Fouad, 2015). There are four Districts in the Al-Najaf governorate: Najaf District, Kufa District, Al-Meshkhab District and Al-Manathera District. The Kufa district is located about (8.99) km eastern of AL-Najaf province (see Figure 1), it positioned geographically (44020'0"–44037'30"E and 31058'30"–32012'30" N) (Abojassim et al., 2018). The province of AL-Najaf is situated in the southwestern region of Iraq, occupying an area of (28537) km^2. The sub-districts under the district of Kufa are the sub-district of Al-Abbassiya and the sub-district of Al-Huriya. We are studying forty locations located in Kufa city to measure natural background radiation and mapping it.

Figure 1 Map of the study area



3 Materials and methods

3.1 Collection and preparation of samples

Forty soil samples were collected from various locations of Kufa city of Al-Najaf governorate, Iraq, at a depth 15 cm from the Earth's surface, according to the recommendation of IAEA. Then, samples were preserved in a plastic pouch, classified according to their collected site and transferred to the nuclear Physics Laboratory, Science college, Physics department, Kufa University for measuring. The coordinates of each soil sample were determined using a GPS device, as shown in Table 1. Also, the GIS (ArcGIS 10.7.1.) results were drowned, as shown in Figure 2. Soil samples (1 kg) were measured directly without any preparation.

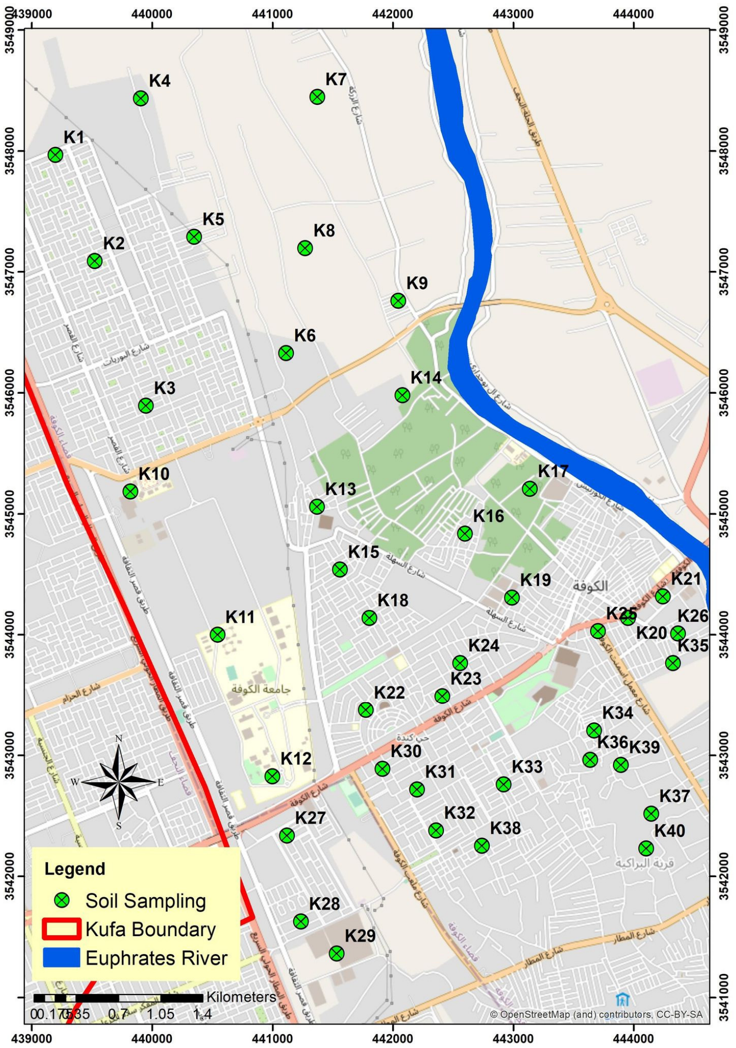
Table 1 Names and locations of soil samples of the present study

No.	*Name of samples*	*Sample code*	*Coordinates*	
1	Maysan 1	K1	44°21'21.5"E	32°03'59.5"N
2	Maysan 2	K2	44°21'33.1"E	32°03'30.5"N
3	Maysan 3	K3	44°21'50.4"E	32°02'51.7"N
4	Alwat Alfahal 1	K4	44°21'47.7"E	32°04'13.8"N
5	Alwat Alfahal 2	K5	44°22'06.1"E	32°03'37.2"N
6	Alwat Alfahal 3	K6	44°22'34.3"E	32°03'06.6"N
7	Alzarga 1	K7	44°22'38.1"E	32°03'39.6"N
8	Alzarga 2	K8	44°22'39.7"E	32°03'34.6"N
9	Alzarga 3	K9	44°23'10.0"E	32°03'20.0"N
10	Middle Euphrates Centre	K10	44°21'46.0"E	32°02'28.2"N
11	Kufa University 1	K11	44°22'13.7"E	32°01'49.7"N
12	Kufa University 2	K12	44°22'30.3"E	32°01'12.1"N
13	Alsahla	K13	44°22'44.8"E	32°02'22.6"N
14	Palm Street area	K14	44°23'11.4"E	32°02'53.1"N
15	Alaskari	K15	44°22'51.3"E	32°02'07.0"N
16	Alsehilia 1	K16	44°23'31.9"E	32°02'17.0"N
17	Alsehilia 2	K17	44°23'51.1"E	32°02'29.1"N
18	Almutanabi	K18	44°23'02.2"E	32°01'54.4"N
19	Aljamea	K19	44°23'45.8"E	32°02'00.1"N
20	Aljomhoria	K20	44°24'22.6"E	32°01'56.2"N
21	Aljdaidaat	K21	44°24'33.2"E	32°02'01.1"N
22	Alshorta	K22	44°23'00.7"E	32°01'30.3"N
23	Kenda 1	K23	44°23'24.2"E	32°01'33.5"N
24	Almolimeen	K24	44°23'29.9"E	32°01'42.8"N
25	Alwakaf	K25	44°24'13.2"E	32°01'50.1"N
26	Alrashadiya	K26	44°24'37.8"E	32°01'50.7"N
27	Industrial District 1	K27	44°22'34.9"E	32°00'56.3"N
28	Industrial District 2	K28	44°22'40.1"E	32°00'32.6"N
29	Almatar	K29	44°22'51.3"E	32°00'24.7"N
30	Tamoz	K30	44°23'04.7"E	32°01'14.3"N
31	Kenda 2	K31	44°23'15.0"E	32°01'07.9"N
32	Maytham Altamaar 1	K32	44°23'23.6"E	32°00'57.3"N
33	Maytham Altamaar 2	K33	44°23'42.9"E	32°01'10.4"N
34	Alsafeer	K34	44°24'11.8"E	32°01'23.4"N
35	Alkareeat	K35	44°24'39.0"E	32°01'48.3"N

Table 1 Names and locations of soil samples of the present study (continued)

No.	*Name of samples*	*Sample code*	*Coordinates*	
36	Alforat 1	K36	44°24'12.1"E	32°01'16.5"N
37	Alforat 2	K37	44°24'30.6"E	32°01'02.6"N
38	Role of cement plant	K38	44°23'36.6"E	32°00'52.9"N
39	Alsadar – Third 1	K39	44°24'21.2"E	32°01'14.8"N
40	Alsadar – Third 2	K40	44°24'31.5"E	32°01'03.0"N

Figure 2 Area of study with sites of samples under investigation



3.2 Detection and measurement system

Background radiation in soil samples of the present study was determined using portable Radiation Alert Inspector dosimeter (S.E. International Inc., USA), as shown in Figure 3.The Radiation Alert Inspector is a microprocessor-based radiation detector with a four-digit LCD digital displaying millirem (mR) per hour and function indicators that detects potentially harmful ionising, particle and x-ray radiation (Alasadi et al., 2016). This radiation detector can detect low levels of the four main types of ionising alpha and beta particles and gamma rays and x-rays over automatic operational ranges. A 2" halogen-quenched, uncompensated Geiger Mueller (G.M.) tube with a small mica end window for sensing ionising radiation is used in the radiation detector. The centre of the detector for scanning Naturally Occurring Radioactive Material (NORM) contamination, gross wipe counting, contamination inspection of products, equipment, and people, regulatory assessments and low energy radionuclide detection is marked by a radiation symbol on the front label (Ahmed, 2012). Portable of Inspector Exp$^+$ calibrated using magnification company which equals 3340 CPM/mR/h".

Figure 3 Portable radiation alert Inspector dosimeter (Al-Taweel and Alasadi, 2018)

3.3 Calculations

The dose rate (D) of background radiation in soil samples from the current investigation was calculated using a portable radiation Alert Inspector dosimeter in units of Sv/h, which was then multiplied by 8766 to get the Annual Average Effective Dose (AAED) in units of mSv/y (Attix, F.H. and Tochilin, 2016; Beyzadeoglu, 2010). To find Excess Lifetime Cancer Risk (ELCR) using equation (1) that depend on AED (mSv/y), DL is the average lifespan (which equal 70 years) and R.F. is the conversion factor (which equal

0.05 1/Sv according to ICRP, 2007) (Haghparast et al., 2020; Dhahir et al., 2020; Abojassim and Rasheed, 2021):

$$ELCR = AED \times DL \times RF \quad (1)$$

4 Results and discussion

Table 2 shows the results of background in soil samples. From Table 2, the values of dose rates were ranged from 0.047±0.005 µSv/h to 0.203±0.020 µSv/hr, with an average value of 0.127±0.005 µSv/h.Results of AAED ranged (0.41 mSv/y–1.78 mSv/y), an average value of 1.15±0.04mSv/y, while ELCR ranged (1.44×10^{-3} –6.22×10^{-3}), an average value (3.90±0.15) × 10^{-3}. The highest dose rate value is found in sample K22 from Alshorta districts, while the lowest was in sample K39 from Alsadar – Third 1 districts. Background radiation measured in soil samples using a portable dosimeter has different values in each study area. This difference could be related to a difference in the geographical nature of each region, such as soil type (Clay or sand). In all present study samples, the dose rate and AAED were compared with the global standard values, as shown in Figures 4 and 5, respectively. From Figure 4, the dose rate values in all present study samples were lower than the global limit that recommended value of 0.274 µSv/h (Emelue, 2020; Okoye and Avwiri, 2013). Also, from Figure 5, all values of AAED were lower than the global limit that recommended value 2.4 mSv/y according to UNSCEAR 2008 report (United Nations Scientific Committee on the Effects of Atomic Radiation, 2010; Schauer and Linton, 2009). Also, the value of the results of ELCR was little; therefore, the risk of cancer is negligible. Comparison between background according to dose rate in µSv/h, AAED in mSv/y and ELCR for all the samples as shown in Figures 6, 7 and 8 drawn by To differentiate between high, medium and low numbers, GIS technology was applied. At last, from the results of background radiation for the soil samples in Kufa districts were safe areas.

Table 2 Results of exposure, D, AAED and ELCR in soil samples of the present study

No.	*Sample code*	*Dose rate (µSv/h)*		*AAED (mSv/y)*	*ELCR×10^{-3}*
		Average	*±S.D.*		
1	K1	0.083	0.008	0.73	2.54
2	K2	0.137	0.014	1.20	4.20
3	K3	0.113	0.011	0.99	3.46
4	K4	0.131	0.013	1.15	4.02
5	K5	0.095	0.010	0.83	2.91
6	K6	0.131	0.013	1.15	4.02
7	K7	0.089	0.009	0.78	2.73
8	K8	0.119	0.012	1.04	3.65
9	K9	0.107	0.011	0.94	3.28
10	K10	0.155	0.016	1.36	4.75
11	K11	0.137	0.014	1.20	4.20
12	K12	0.191	0.019	1.67	5.86
13	K13	0.113	0.011	0.99	3.46
14	K14	0.143	0.014	1.25	4.38
15	K15	0.167	0.017	1.46	5.12

Table 2 Results of exposure, D, AAED and ELCR in soil samples of the present study (cont..)

No.	*Sample code*	*Dose rate (μSv/h)*		*AAED (mSv/y)*	*ELCR×10^{-3}*
		Average	*±S.D.*		
16	K16	0.143	0.014	1.25	4.38
17	K17	0.185	0.019	1.62	5.67
18	K18	0.155	0.016	1.36	4.75
19	K19	0.079	0.008	0.69	2.42
20	K20	0.131	0.013	1.15	4.02
21	K21	0.125	0.013	1.10	3.83
22	K22	0.203	0.020	1.78	6.22
23	K23	0.107	0.011	0.94	3.28
24	K24	0.131	0.013	1.15	4.02
25	K25	0.137	0.014	1.20	4.20
26	K26	0.107	0.011	0.94	3.28
27	K27	0.089	0.009	0.78	2.73
28	K28	0.125	0.013	1.10	3.83
29	K29	0.161	0.016	1.41	4.94
30	K30	0.101	0.010	0.88	3.10
31	K31	0.179	0.018	1.57	5.49
32	K32	0.143	0.014	1.25	4.38
33	K33	0.125	0.013	1.10	3.83
34	K34	0.131	0.013	1.15	4.02
35	K35	0.119	0.012	1.04	3.65
36	K36	0.149	0.015	1.31	4.57
37	K37	0.101	0.010	0.88	3.10
38	K38	0.113	0.011	0.99	3.46
39	K39	0.047	0.005	0.41	1.44
40	K40	0.095	0.010	0.83	2.91
Average±S.E		0.127±0.005		1.12±0.04	3.90±0.15
Global limit		0.247[8, 9]		2.4 [19, 20]	--------

Figure 4 Comparison of the results of dose rate in the present study with global limit

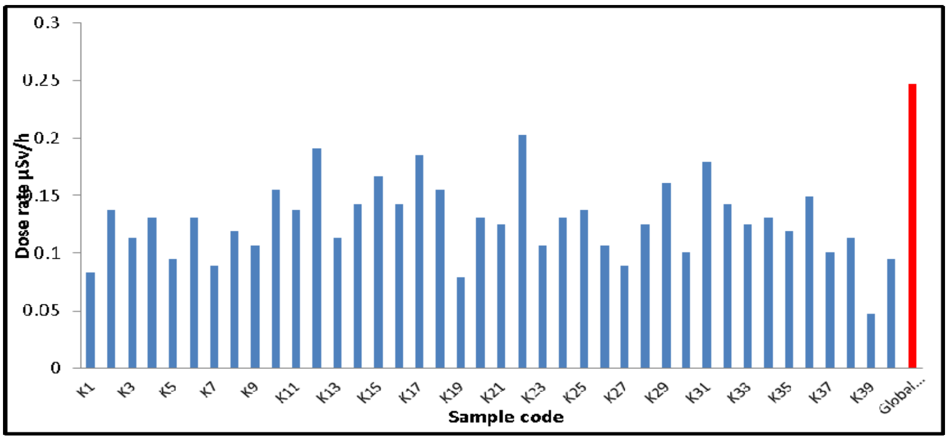


Figure 5 Comparison of the results of AAED in the present study with global limit

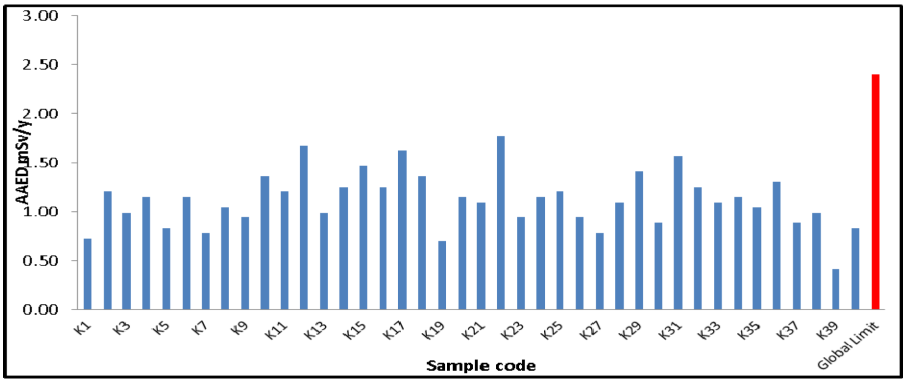


Figure 6 The choropleth maps of the values of dose rate in the present study

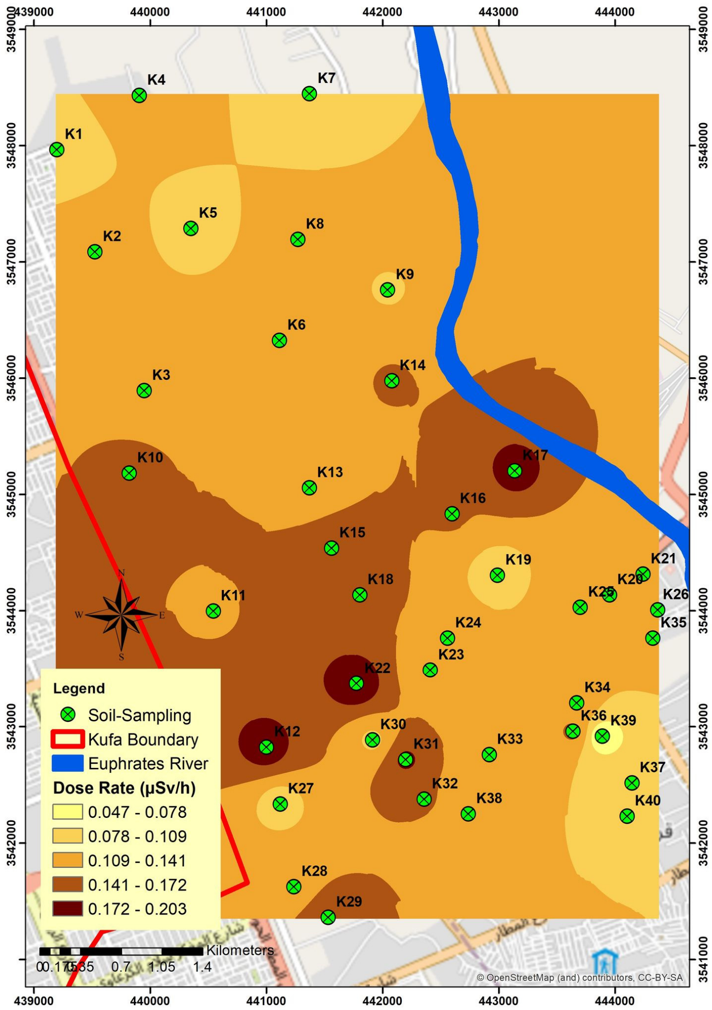


Figure 7 The choropleth maps of the values of AAED in the present study

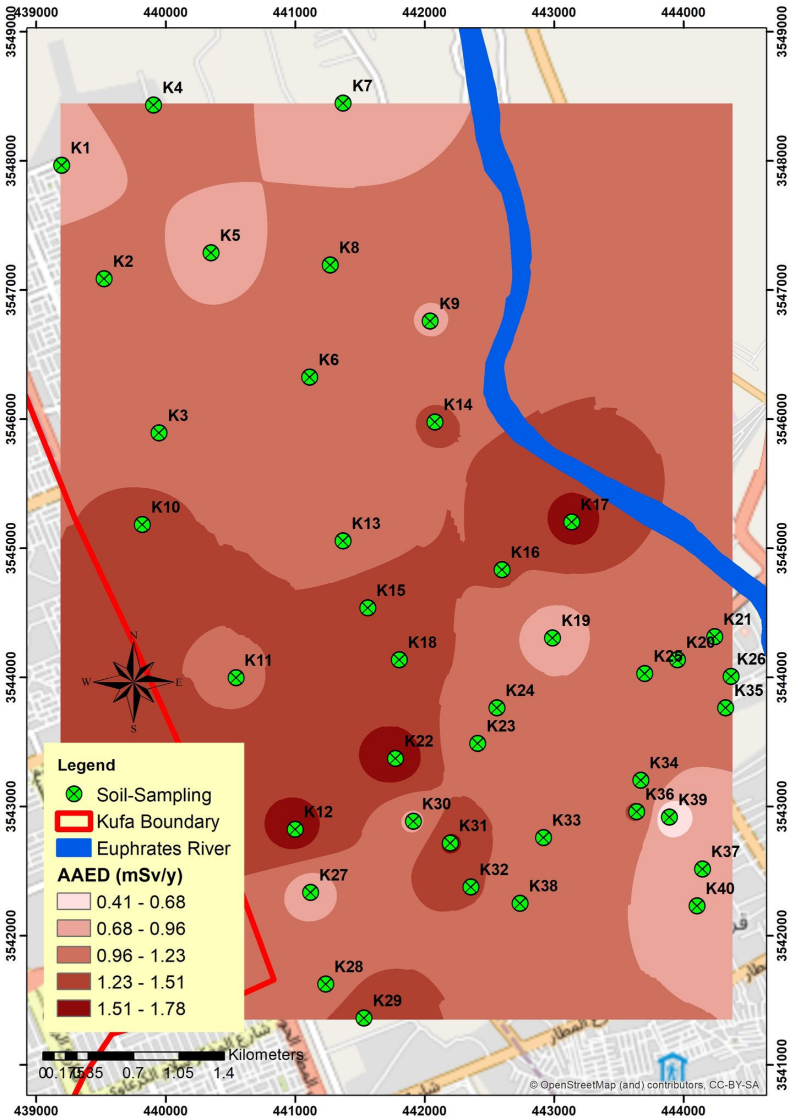
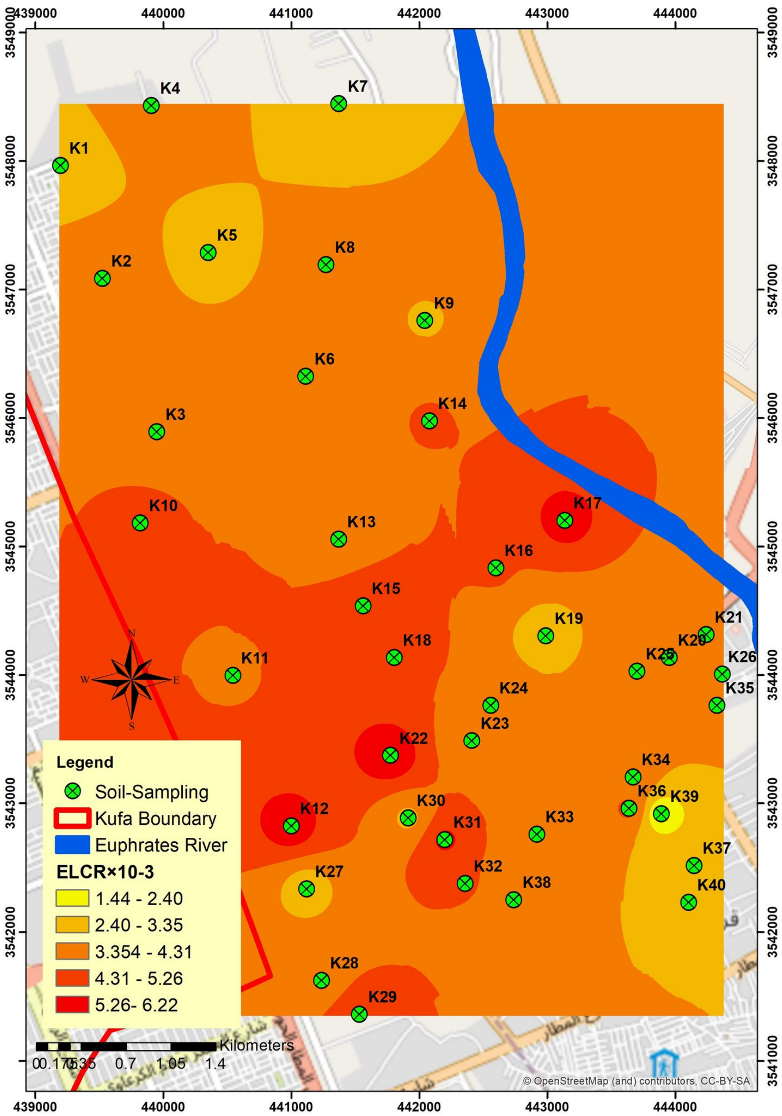


Figure 8 The choropleth maps of the values of ELCR in the present study



When the average AED due to background radiation in Kufa city was compared to the averages in several nations, it was discovered that the average was greater than Nepal, Nigeria, Egypt and Iran, but lower than India, as indicated in Table 3.

Table 3 Comparison of the results in the present study with other studies

No.	*Countries*	*AED (mSv/y)*	*Reference*
1	India	7.56	Monica et al. (2016)
2	Nepal	0.56	Gautam et al. (2020)
3	Nigeria	0.53	Ajayi et al. (2008)
4	Egypt	0.39	El-Taher et al. (2007)
5	Iran	0.40	Haghparast et al. (2020)
6	Present study	1.15	--------

5 Conclusions

Through the background radiation results in soil samples collected from most sites of Kufa districts, residents in the research region were found not to have been exposed to any harmful radiation. There were no harmful radiation effects on the people, according to the findings, who live in the study area. Also, GIS technology was used to analyse soil samples by mapping of dose rate, annual average effective dose and excess lifetime cancer risk due to background radiation.

References

Abojassim, A.A. and Rasheed, L.H. (2021) ‘Natural radioactivity of soil in the Baghdad governorate’, *Environmental Earth Sciences*, Vol. 80, No. 1, pp.1–13.

Abojassim, A.A., Alzurfi, S.K.L. and Mraity, H.A.A. (2018) ‘Monthly monitoring of physicochemical and radiation properties of Kufa River, Iraq’, *Pakistan Journal of Scientific and Industrial Research Series A: Physical Sciences*, Vol. 61, No. 1, pp.43–50.

Ahmed, R.K. (2012) ‘Measurement of the average gamma rate radiation for some regions in Baghdad city’, *Journal of Kufa Physics*, Vol. 4, No. 1, pp.48–55.

Ajayi, O.S., Ibikunle, S.B. and Ojo, T.J. (2008) ‘An assessment of natural radioactivity of soils and its external radiological impact in southwestern Nigeria’, *Health Physics*, Vol. 94, No. 6, pp.558–566.

Alasadi, A.H., Alaboodi, A.S., Alasadi, L.A. and Abojassim, A.A. (2016) ‘Survey of absorbed dose rates in the air of buildings agriculture and sciences in University of Kufa at Al-Najaf governorate, Iraq’, *Journal of Chemical and Pharmaceutical Research*, Vol. 8, No. 4, pp.1388–1392.

Attix, F.H. and Tochilin, E. (Eds) (2016) *Sources, Fields, Measurements, and Applications: Radiation Dosimetry*, Vol. 3, Academic Press.

Beyzadeoglu, M., Ozyigit, G. and Ebruli, C. (2010) *Basic Radiation Oncology*, Springer Science & Business Media.

Dhahir, D.M., Mraity, H.A., Abojassim, A.A., Najam, L.N. and Al-kazrajy, H.Y.Y. (2020) ‘Natural radioactivity levels in soil samples of some schools in Al-Shatrah city at DhiQar governorate, IRAQ’, *Malaysian Journal of Science*, pp.104–114.

El-Taher, A., Uosif, M.A.M. and Orabi, A. (2007) ‘Natural radioactivity levels and radiation hazard indices in granite from Aswan to Wadi El-Allaqi southeastern desert, Egypt’, *Radiation Protection Dosimetry*, Vol. 124, No. 2, pp.148–154.

Emelue, H.U. (2020) *Measurement of Background Ionizing Radiation in the Federal University of Technology Owerri, Nigeria using Calibrated Digital Geiger Counter*, Research.

Gautam, S.P., Silwal, A., Acharya, S. and Aryal, B. (2020) 'annual effective dose from natural background radiation in Pokhara, Nepal', *Asian Journal of Research and Reviews in Physics*, pp.36–42.

Haghparast, M., Ardekani, M.A., Navaser, M., Refahi, S., Najafzadeh, M., Ghaffari, H. and Masoumbeigi, M. (2020) 'Assessment of background radiation levels in the southeast of Iran', *Medical Journal of the Islamic Republic of Iran*, Vol. 34, pp.1–4.

Al-Taweel, M.H. and Alasadi, L.A. (2018) 'Measurement of Gamma Radiation dose for selected samples of Kufa University at Al-Najaf Governorate, Iraq', *Proceedings of the 2nd International Symposium on Multidisciplinary Studies and Innovative Technologies (ISMSIT)*, IEEE, pp.1–3.

Harrison, R.M. (Ed.) (2001) 'Pollution: causes, effects and control', *Royal Society of Chemistry*.

Hendry, J.H., Simon, S.L., Wojcik, A., Sohrabi, M., Burkart, W., Cardis, E. and Hayata, I. (2009) 'Human exposure to high natural background radiation: what can it teach us about radiation risks?', *Journal of Radiological Protection*, Vol. 29, pp.A29–A42.

Hosoda, M., Nugraha, E.D., Akata, N., Yamada, R., Tamakuma, Y., Sasaki, M. and Tokonami, S. (2021) 'A unique high natural background radiation area – dose assessment and perspectives', *Science of The Total Environment*, Vol. 750. Doi: 10.1016/j.scitotenv.2020.142346.

Hussein, A.K., Kadhim, N.A., Jaber, A.S. and Abojassim, A.A. (2020) 'Water quality index for surface water assessment by using gis techniques, Alnajaf, Kufa, Iraq', *IOP Conference Series: Materials Science and Engineering*, Vol. 928, No. 7, pp.1–11.

Khader, R.B. (2010) 'Measure the background radiation in some parts of Nineveh Province', *Rafidain Journal of Science*, Vol. 21, No. 4, pp.92–104.

Monica, S., Prasad, A.V., Soniya, S.R. and Jojo, P.J. (2016) 'Estimation of indoor and outdoor effective doses and lifetime cancer risk from gamma dose rates along the coastal regions of Kollam district, Kerala', *Radiation Protection and Environment*, Vol. 39, No. 1, pp.38–43.

Okoye, P.C. and Avwiri, G.O. (2013) 'Evaluation of background ionizing radiation levels of braithwaite memorial specialist hospital Port Harcourt Rivers State', *American Journal of Scientific and Industrial Research*, Vol. 4, No. 4, pp.359–365.

Schauer, D.A. and Linton, O.W. (2009) 'NCRP Report No. 160, ionizing radiation exposure of the population of the United States, medical exposure – are we doing less with more, and is there a role for health physicists', *Health Physics*, Vol. 97, No. 1, pp.1–5.

Sissakian, V.K. and Fouad, S.F. (2015) 'Geological map of Iraq, scale 1: 1000 000, 2012', *Iraqi Bulletin of Geology and Mining*, Vol. 11, No. 1, pp.9–16.

United Nations Scientific Committee on the Effects of Atomic Radiation (2010) *UNSCEAR 2008 report Vol. I: Sources of ionizing radiation*, United Nations, New York.

United Nations Scientific Committee on the Effects of Atomic Radiation (2010) *UNSCEAR 2008 Report Vol. I: Sources of Ionizing Radiation*, United Nations, New York.