Research Article

Radiological characterization of Nahrawan site in Baghdad governorate using portable radiation devices

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Abstract: Radioactive contamination occurred at the Nahrawan site as a result of the use of the US military depleted uranium in the war of 2003, which led to contamination of a certain area of this city. The aim of this study is the characterization of contaminated areas in the AL-Nahrawan site using portable exposure Geiger miler devices and the surface contamination is measured by Radeye AB100 (ZnS(Ag)) scintillation detector Alpha-Beta Contamination Monitor from a thermos. It was found that the values of the surface contamination ranged above the background the values of surface contamination are 0.46 to 50.9 Bq/cm2 and the values range of radiation exposure are 0.016 to 1.823 m R/hr. The average dose rate is (0.104mRad / hr) and the average surface contamination is (2.88 Bq/cm2). The radiation exposure and surface contaminated survey are using to draw the radiological map for the AL-Nahrawan site in order to determine the contaminated area and values of radioactive waste in the AL-Nahrawan site.

Keywords: exposure, radioactive contamination, Depleted uranium, characterization, gamma spectrometer.

1. Introduction

Radiation is described according to its energy and type[1]. .Natural sources include cosmic rays are particles and photons that originate from outside the earth's atmosphere, and the main source of this radiation is the sun and galaxies. The cosmic rays consist of particles with high energy, amounting to 87% protons, 12% alpha particles, and 1% of electrons with high energy. Cosmic rays interact with the atmosphere by nuclear reactions that form radioactive products[2]. Natural radionuclide of terrestrial origin are primitive and present to varying degrees in all environmental elements. Radioactive decay contributes to exposing the population to radiation risks, either through external exposure to radioactive materials deposited on the ground, or through inhalation and ingestion of radioactive materials suspended in the air, or from the way food and water containing radioactive materials are consumed[3]. Uranium is a heavy metal and radioactive element found in the earth [4,5]. Natural uranium consists of isotopes of uranium^{238}U, ^{235}U, and ^{234}U with weight ratios of 99.28%,0.71%, and 0.0055% respectively[6]. These three radioisotopes have half-lives 4.5×10^9,7.1×10^{10} and 24.7×10^5years, respectively[7]. Depleted uranium has the same three radioisotopes as natural uranium, but the ratio is different from natural uranium. The isotope content of ^{235}U is reduced from 0.71% to 0.2% -0.3% during the enrichment process and the irradiance concentration of ^{234}U will be around (0.005% - 0.0020%). Depleted uranium has a percentage higher than ^{238}U (99.8 %) of naturally present uranium[8]. Scientific studies are investigating the study of uranium concentrations in soil and water due to the effect of its radioactivity on the environment [9]. Radiation toxicity is a measure of the harm that radionuclides cause to human health through inhalation or ingestion and depends on the type and energy of the radiation emitted from the radionuclides, in which the harm occurs to the person due to the external dose and internal radioactive contamination[10]. The danger of uranium metal is its ability to change the shape of a living cell in a DNA cell, which causes cancer cells [11]. Conducting radiological surveys of contamination site was done by measuring the radioactive concentrations and calculating the amount of exposure and contamination for the radioactive materials, and comparing them with international standards for divorce. The radiological surveys are carried out with a high degree of certainty and accuracy, they must meet the criteria of the Nuclear Regulatory Commission (NRC). The average grid area was based on 100 m2 (10 m x 10 m). Exposure rates do not exceed background levels by more than the exposure rate limit, 1 meter from the roof, inhabitable building sites [12]. Grid systems are created on-site to facilitate the order. These grids consist of a system of intersecting lines. Gridlines are usually arranged in a coordinate system in which the survey site is divided into squares of equal types of patterns (triangle, rectangular, hexagonal) the coordinate systems are marked (W, N, E) as a 3-dimensional coordinate for an open area using a chalk line or paint marking on the floor surface. Direct measurements for alpha-emitting radionuclide are generally performed by placing the detector on or near the surface to be measured. The limited range of alpha and beta particles (about 1 cm less from the surface of the earth) [13].

2. study area

Baghdad has a population of about 8.5 million in 2016, making it the largest city in Iraq, the second-largest city in the Arab world, and the second-largest city in Western Asia [14]. Nahrawan is part of Baghdad, the capital of Iraq. The study area is in a circle of latitude (33.272637) in the north and longitude (44.610383) in the east. Fig. (1 and 2). (A) shown a map of Iraq, and (B) shown the location of Al-Nahrawan and the study area using GPS**.**

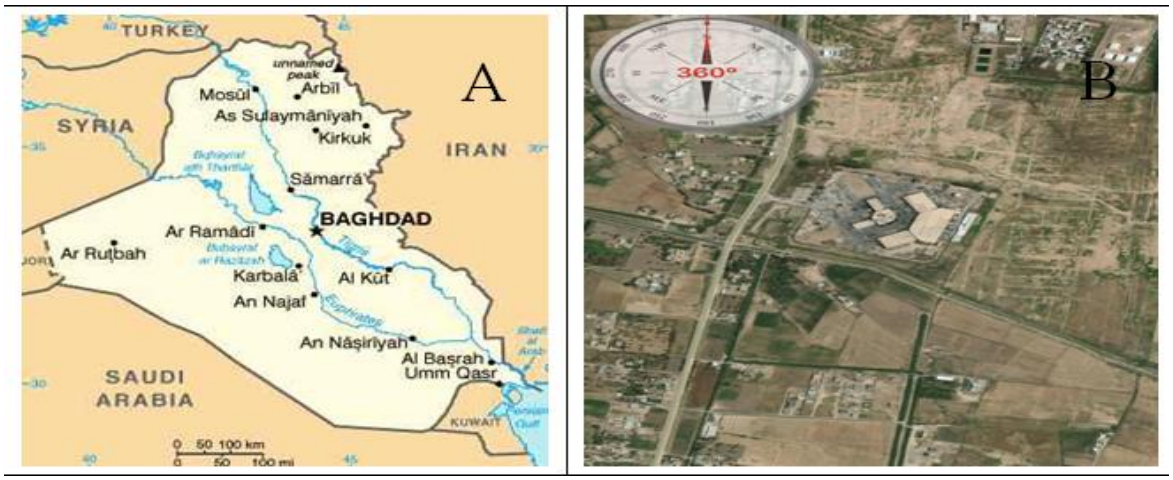

Figure.1. (A) The Iraq map and (B) Al- Nahrawan site.

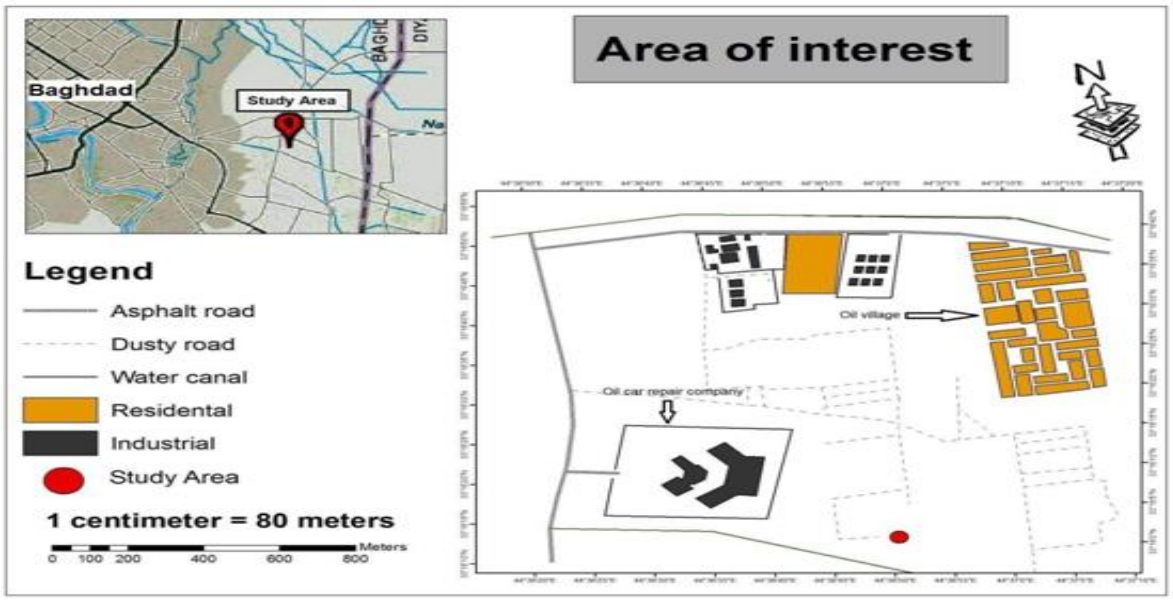

Figure .2. The map of AL-Nahrawan site and the study area.

3. Materials and Methods

3.1 Measurements

surface contaminated activity for AL-Nahrawan site using portable devices are suitable in measuring the dose rate and surface contamination of all types of radiation such as alpha, beta particles, and gamma rays and have high efficiency and high sensitivity to detect radiation and have been calibrated to a type (^{137}Cs) radioactive source.

3.1.1 Background Measurements

To see radiation levels or radioactivity levels above normal background for the studied area, background radiometry is necessary. Background radiation measurements were made with similar characteristics for unaffected areas to provide reference data on the natural background and to distinguish between the radiation background of the clean area. The measurements were made for a clean area one kilometer away from the

contaminated site dose rate measured by Inspector device (G.M), the surface contamination measured by Redeye (ZnS(Ag)) scintillation detector, and taken the GPS for each point that measuring it shown in Table 1. And Fig. 3. Shown coordinate locations about the clean areas surrounding the radioactively contaminated area with a distance of one kilometer.

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Table. 1. Background measurements(dose rate &surface contamination) at One km away from the site using portable devices.

Position	**Dose rate ave mR/hr**	**Surface Contamination ave Bq/cm^2**	**GPS**
P_1	0.012	0. 19	N33.277394 E44.615085
P_2	0.011	0. 17	N33.262835 E44.621116
P_3	0.012	0.20	N33.262528 E44.604867
P_4	0.013	0.22	N33.271588 E44.602709
Max	0.013	0.22	
Min	0.011	0.17	
Ave	0.012	0.19	

Figure.3. Coordinate locations show the clean areas surrounding the radioactively contaminated site**.**

3.1.2 Surface contamination characterization

Scintillation instruments were used for measurement surface contamination that could determine all types of X-rays and gamma radiation [15]. The electronic parts of the instruments cause their overall size to be similar to that of ion chambers, the detecting volume can be much smaller. Although a 1 cm^3 crystal is often adequate, the higher sensitivity of larger crystals permits their use for measurements of dose rates at natural background levels.

The surface contamination was measured using a portable detector Redeye AB100 (ZnS(Ag)) scintillation detector and aluminized plastic film from Thermo Scientific was used to measure surface contamination in the AL-Nahrawan site. It is measuring in units (Bq / cm²) which has efficiency for Am-241radionuclides (α) =36% Co-60= 23 % (β) Sr/Y-90 = 49 % (β) , with window has thickness0.87 mg/cm²,active area(sensitive area of 69mm x 145 mm)[16]. To determine the natural background radiation, the locations far away from the contaminated site(about 1km) were chosen as shown in Fig.4. Measuring clean area (B.G) for the site was 0.17 Bq/cm^2 comparing with surface contamination measuring in the contaminated area was 37. 7 Bq/cm^2.

Figure.4. Radiation measuring device type Radeye AB100

3.1.3 Measurements of Dose Rate

Thin-walled or thin windowed Geiger–Müller counters are used in this study to the radiation survey in the AL-Nahrwan Site for the detection of beta radiation. If the counter is provided with a cover that is sufficiently thick to stop beta radiation, the difference between readings with and without the cover can be used to distinguish between beta Particles and gamma rays(including Sun rays). Geiger–Müller detectors with thin and windows, in particular, may have acceptable energy dependence for beta dose rate monitoring in the workplace and have the additional advantage of having a small size that is capable of detecting a relatively low dose rate. The radioactive dose from exposure in the AL-Nahrawan site due to the natural background radiation is measured using a portable detector inspector is a portable Geiger Miller counter with supersensitivity to detect radioactive materials. It is measured in units (mR/hr or µSv/hr), window diameter is 45 mm, measuring alpha, beta, gamma, and x-ray, the detecting efficiency for alpha at 3.6MeV 80%, the detecting efficiency for the beta at 50 keV was 35% the at 150 keV was 75%. Detecting efficiency for gamma and x-rays down to 10 keV by window and operating ranges 0.001 to 100 mR/hr, 0.01 to 1000 µSv/hr, and 0 to 350,000 CPM, 0 to 5,000 CPS, Total counts from 1 to 9,999,000.Calibration standard was done using Cs-137 gamma source made in USA[17]. Fig .5. shown the radiation dose measuring the touch of background(clean area outside the site) and the radiation dose is 0.0013mR/hr is the (BG) due to the natural background radiation comparing with the radiation dose Measuring for the contaminated area the radiation dose was 26.92 mR/hr.

Figure.5. Radiation measuring device, type Inspector.

3.2 Radiological Survey

Grid systems were established at AL-Nahrawan site systematic selection of measuring sampling locations. a mechanism for referencing a measurement/sample back to a specific location was done so that the same survey point can be relocated. A convenient means for determining average activity levels were provided. A grid consists of a system of intersecting lines. Typically, the grid lines are arranged in perpendicular patterns, dividing the survey location into squares or blocks of equal area. Grid patterns on horizontal surfaces are usually and alphabetically on the other axis or in distances from the grid origin. AL-Nahrawan site with area 200×175 m^2. Divided the survey location into squares as blocks of equal area. Two classifications of areas are used in this study; these termed-affected (contaminated with (DU) and unaffected areas (Clean areas) and therefore do not require the same level of survey coverage. Contaminated areas have hot spots and needed this area's higher degree of radiation survey (the contaminated area in this study divided into squares areas 25 m^2). To be the survey process will be both effective and efficient, the unaffected areas (Clean areas) that not recording any radiation dose above the background value in radiation survey in this study it has squares area of 625m^2. All these surveys for investigation of radiation exposure and surface contamination this process are doing for putting radiation map for AL-Nahrawan Site. Figs. (6 and 7). Shown a grid system for a survey of ground site coordinate systems are marked (W, N, E) is 3-dimensional coordinate using paint marking on the floor surface. Along the entire line of the grid or at the intersections of the line. Selection of an appropriate marker to denote the divided grid of the site by painting in the radiological survey the contaminated site(Measurement Surface contaminate in 1 cm and Dose Rate in 1m) with radiations measurements documentation and radiation map of radioactive contamination. Fig.(8 and 9). Shown the radiation measurement of the surface contamination and dose rate of the contaminated site using coordinates Google earth.

Figure.6.A grid system for survey of site grounds

Figure.7. Radiological survey the contaminated site with documentation with radiation measurements

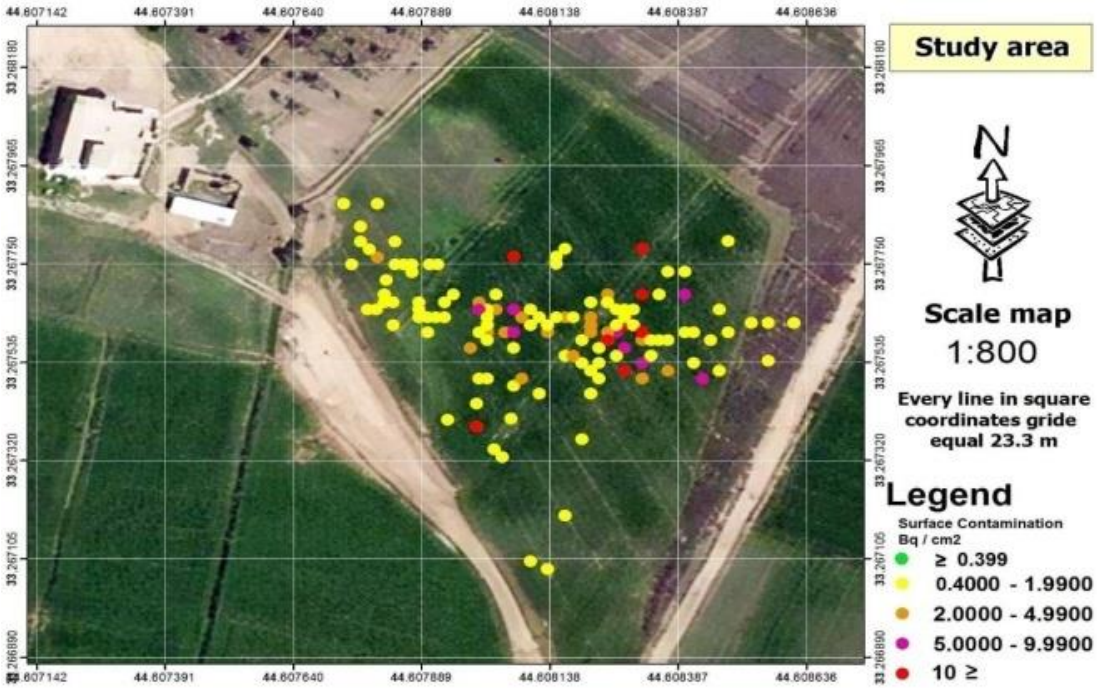

Figure.8. The surface contamination of the contaminated site by use coordinates

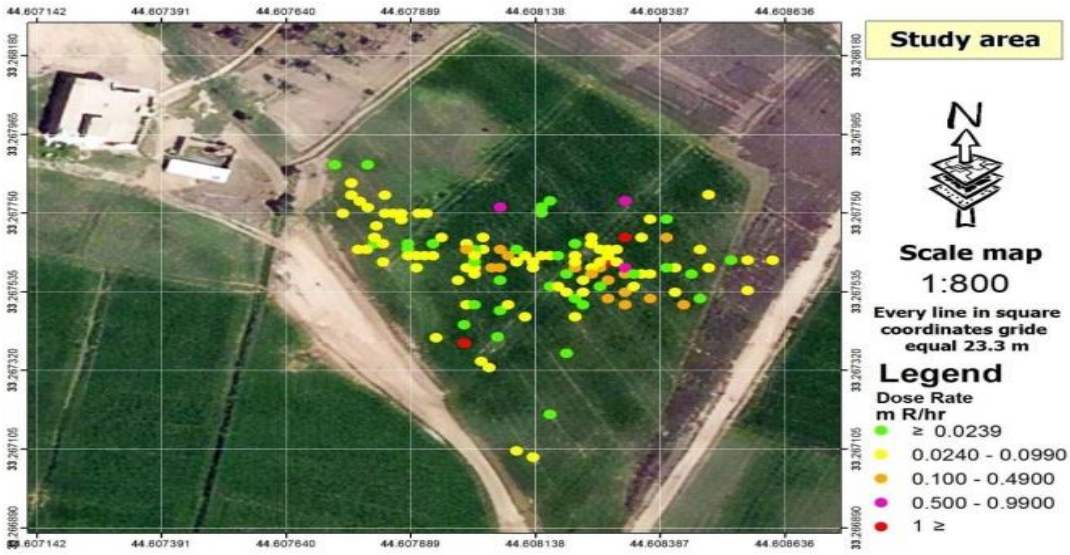

Figure.9. The dose rate of the contaminated site by use coordinates

3.3 Calibrator for high purity germanium detector

The standard mix source contains many energies to give a wide field radionuclide with multiple energies saved for a one-liter capacity in a Marinelli beaker were used for energy calibration of Ultra-pure germanium. The measurements were taken for 3600 s and a linear relationship between energies was obtained. For the purpose of measuring the background radiometry, the experiment was measured with an empty Marinelli container. As for the soil samples, they were collected and cleaned from Gravel and impurities and dry them at a temperature of 85Cº then it was ground and screened using a 1mm diameter sieve, then it was placed in a 500 g. Table .2. Shown presents the efficiency of HPGe detector using mixed standard source, the energy, and efficiency calibration curves were shown in Figs. (10 and 11).

Table.2. Themixed standard source radionuclide's

No	Radionuclide	E keV	Efficiency
1	^{241}Am	59.54	0.031096
2	^{109}Cd	88	0.023606
3	^{57}Co	122	0.018691
4	^{137}Cs	661.66	0.0055875
5	^{60}Co	1332.3	0.0033904

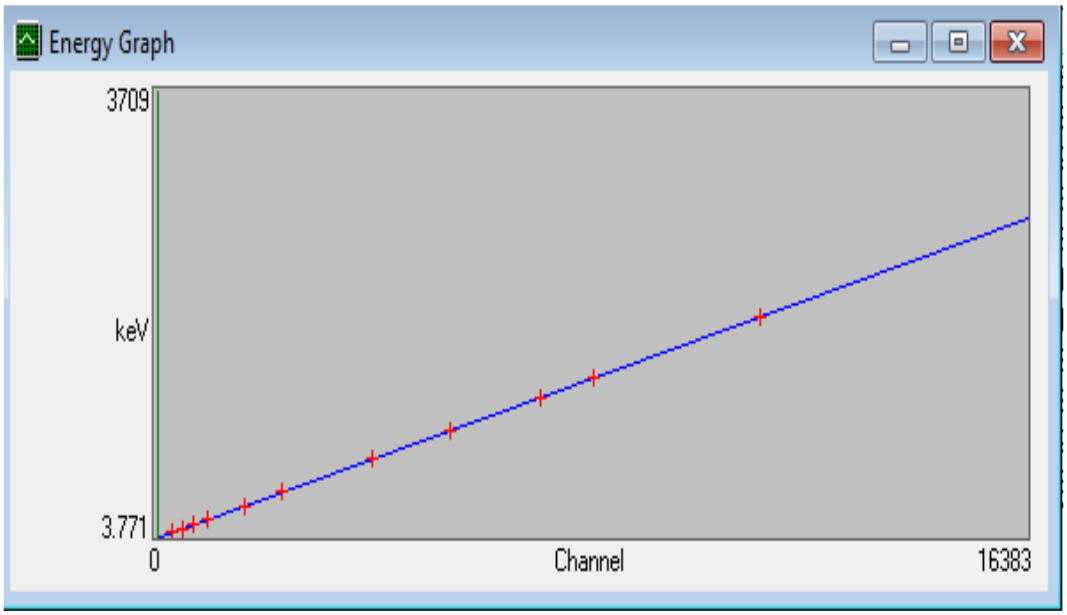

Figure.10. The linearity energy calibration curve between energy and channel number

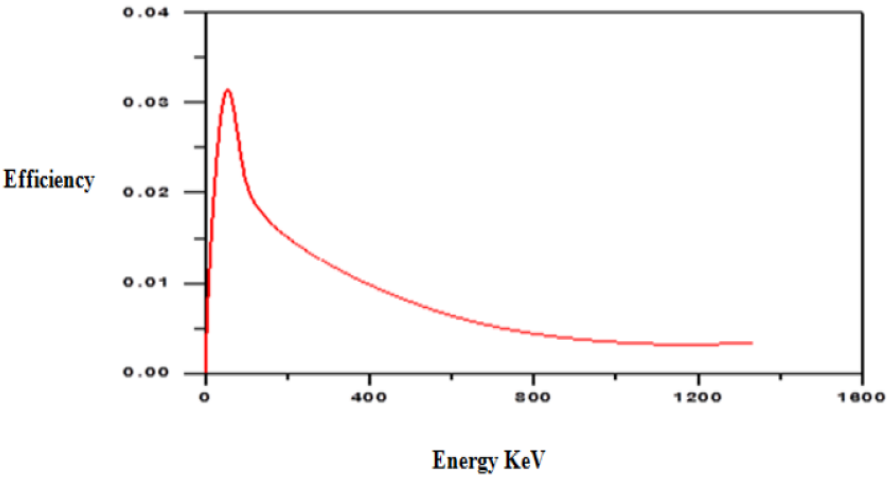

Figure.11. The efficiency calibration curve between detector efficiency and energy.

4. Results and discussion

Al-Nahrawan site is contaminated with DU that used by USA forces in war 2003. The radiation dose and surface activity have high values comparing with the clean area near the AL-Nahrawan site as presented in Table. 3 and figs (8,9). It is noted the highest readings of radioactive contamination levels at a height of 1cm is 50.9 Bq/cm^2 and dose rate at a height of one meter was 1.823 mR / hr and the average exposure for the contaminated area was 0.104mR/hr. The average value of surface contamination was 2.88 Bq/cm^2. These values are very high compared with the average BG value for the clean area was 0.19 Bq / cm^2, (0.012 mR / hr. Table.4. Shown in Radionuclide concentration of 5 soil samples at different depths through laboratory analysis using the (HPGe).

Table .3. The measurements of dose rate and surface contamination in coordinates of the study area

surface contamination using RadEye in unit Bq/cm^2			Dose rate using Inspector in unit mR/hr		
Min.	Max.	Aver.	Min.	Max.	Aver.
0.46	50.9	2.889	0.016	1.823	0.1046
Coordinates of the study area					
N			E		
33^O.272637			44^O.610383		

Table.4. Radionuclides concentration for 5 soil samples

Sample code	**Deep cm**	**^{238}U (^{234m} Pa) 1001 keV**	**^{40}K 1460 keV**	**^{235}U 205keV**	**^{235}U / ^{238}U**
S1	0-5	2572.75±2.18	93.59±0.84	15.15±0.35	0.0058
S2	0-5	10080.14±9.82	295.9±2.71	42.33±0.70	0.0042
S3	30-50	3492.46±22.70	159.09±13.34	11.83±2.65	0.0033

S4	0-5	4123.10±4.0	8.5±0.87	15.51±0.12	0.0037
S5	10-30	1266±0.96	144.59±1.19	4.4±0.04	0.0034
Max.		10080.14±9.8	295.9±2.71	42.33±0.70	0.0058
Min.		1266±0.96	8.5±0.87	4.4±0.04	0.0033
Ave.		4306.89	140.33	17.84	0.004

5. Conclusions

The area of the contaminated Nahrawan site is 3000 square meters contaminated with depleted uranium through laboratory analysis using the (HPGe) detector by measuring some samples taken from the contaminated site. The radiation dose in the AL-Nahrawan site higher than the average value of the clean area, the surface contamination was 0.19 Bq / cm^2, and radiation dose (0.012 mR / hr) comparing with the average values of radiation dose and surface contamination in AL-Nahrawan contaminated site was (0.104mR/hr) and (2.88Bq/cm^2) the contaminated area have a lot hot spot that has radiation dose above the accepted limited for public according to the IAEA.

References

1. Powsner A.R and Edward R. P. 2006. Essential Nuclear Medicine Physics, ^{2}ed .Blackwell.DOI:10.1002/9780470752890
2. Sharma.S .2008. Atomic and Nuclear Physics. Pearson Education India. pp: 620
3. Gary W. Philips.; David J. Nagel.; Timothy. C. 2005. A Primer on the Detection of Nuclear and Radiological Weapons, Center for Technology and National Security Policy, National Defense University.
4. Msoud. M…….2020. Uranium Adsorption from Bahariya Oasis leach liquor via TOPO Impregnated Bentonite Material; Isothermal, kinetic and Thermodynamic Studies. Egypt.J.Chem. Vol. 63, No. 2. pp. 721-741.
5. Magda A. A. and Rabeaa. A. N. 2018. Flotation and Enhanced Spectrophotometric Determination of Uranium (VI) in Environmental Samples. Egypt. J. Chem. Vol. 61, No.2 pp. 337 – 348
6. Hoda A. Mansour , Khaled F. Mahmoud , Hesham M. Kamal , Heba M.A. Mahdy. (2020).Uranium Bio-sorption fromits Processed Waste Solution by Green Algae. Egypt. J. Chem. Vol. 63 No. 10, pp. 4039 – 4054..
7. Danesi. P. and Telleria. D. 2010. Radiological conditions at four selected sites in South Iraq with residues of depleted uranium. Radiological Assessment Reports Series. International Atomic Energy Agency (IAEA).
8. Durante. M. and M. Pugliese. 2003. Depleted uranium residual radiological risk assessment for Kosovo sites. Journal of environmental radioactivity Vol.64(2-3). pp: 237-245.
9. Mahmoud S.A. Shain , Ebtissam A. Saad, Ahmed Shazly , Amir Ezzat , Sayed A. El-Mongy. (2020) Evaluation of Rare Earth Elements in Black Sand and Phosphate ores, EGYPT. Egypt. J. Chem. Vol. 63, No. 11 pp. 4185 – 4193.
10. Asia H.Al-Mashhadani. 2014. Characterization and Classification of Radioactive Wastes from Disposal SiloIraqi Journal of Science, Volume 55, Issue 2 Supplement, Pages 741-749
11. E. A. Haggag et.al. (2021) Kinetic Studies on the Adsorption of Uranium on a Mesoporous Impregnated Activated Carbon. Egypt. J. Chem. Vol. 64, No. 3 pp. 1371 - 1385.
12. Milchikov.A and Davidko. M. 1999. A Radiological Survey approach to use Prior to Decommission: Results from a Technology Scanning & Assessment Project Focused on the Chornobyl NPP. Pacific Northwest National Laboratory.
13. U.S. Nuclear Regulatory Commission Multi-Agency.2000. Radiation Survey and Site Investigation Manual (MARSSIM)..,NUREG-1575, Rev. 1EPA 402-R-97-016, Rev. 1DOE/EH-0624, Rev. 1.
14. World Atlas ,2020.
15. RAMM, W.J., "Scintillation detectors", Radiation Dosimetry, Vol. II: Instrumentation, 2nd edn (ATTIX, F.H., ROESCH, W.C., Eds), Academic Press, New York (1966) Ch. 11
16. RadEye™ AB100 Alpha-Beta Contamination Monitor.
17. Inspector Alert™ Handheld Nuclear Radiation Monitor