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Radiological assessment of cancer risk and Human Health Risk in Bani Waleed city, Libya

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Abstract: Under specific circumstances, the natural radioactive ^{226}Ra, ^{232}Th, and ^{40}K materials can reach dangerous radiological levels. As a result, research on the levels of natural radioactivity in soil is required to estimate the dose to the population, analyze the health risks, and establish a baseline for potential future changes brought on by human activity.

Hyper-pure germanium (HPGe) gamma ray spectrometry was utilized to examine three sites in Bani Waleed, Libya, in order to determine the radiological health risks, excess lifetime cancer risks, and Effective Dose to Different Body Organs (Dorgan) associated with the use of the soil. Nine samples were collected from each of the three sites (Tagrafeet, Sakia, and City Center) at a depth of ten cm, measured and use an HPGe detector, and the results were compared to the global permissible value. The excess lifetime cancer total, both indoor and outdoor average values were lower than the world permissible value, and the results of all different body organs were below the accepted international limits of 1.0 mSv^{-1}, indicating that the radiation levels in the study area are safe and do not pose a health risk to the local population. The results of this research could serve as significant radiometric baseline data for upcoming epidemiological investigation and prosecution and environmental monitoring programs.

Keywords: Bani Waleed, Tagrafeet, Sakia, City Centre, HPGe.

1.0 Introduction

Background radiation that comes from both natural and man-made sources is exposed to humans. Commonly, natural radioactive elements of both terrestrial and cosmic origin account for 85% of a person's annual total radiation dose [1], [2]. According. A person has a higher risk of developing cancer the more radiation they receive. There is no level below which we can say an exposure does not pose a risk to life, and the cancer may not manifest itself for many years (typically 10 to 40 years) after the radiation dose is received [3].

Because these substances emit radiation as a result of the breakdown of natural radionuclides and contribute to the total absorbed dose through ingestion, inhalation, and external irradiation, the study of the radioactive components in soil is a key component in understanding the behavior of radioactivity in the ecosystem [4] The researchers, who have led the surveys across the world are therefore very interested in measurements of natural radioactivity in soils and radiation doses. [5],[6].

There have been many surveys to determine the background levels of radionuclides in soils which have been turned out to calculate the absorbed dose in air [7].

This paper presents the indoor and outdoor the annual effective dose equivalent rate (AEDE) and the excess lifetime cancer risk (ELCR) and Effective Dose to Different Body Organs (D_{organ}) for the occupationally exposed and nonoccupationally exposed living within Bani Waleed City.

2.0 Supplementary Materials And Methods

2.1 Research area

City of Bani Waleed located at170 kilometres south of Tripoli, at 14 00 50" E and 31 45 43" N, and about 837 feet above sea level as shown in Fig 1. The city has a population of about 100,000. The structural geology of the area mainly sedimentary rocks with minor metamorphic and igneous rocks distributed at the surface It is famous by olive trees, which extends along the valley. The city is characterized by a semidesert climate, where the temperature in summer reaches 45 degrees Celsius and drops to about 15 degrees Celsius in winter. The city of Bani Waleed was subjected to two wars in 2011 and 2012, which caused complete destruction to some places, including the three sites as shown in Fig. (1a, 1b and 1c) that are investigated in this study.

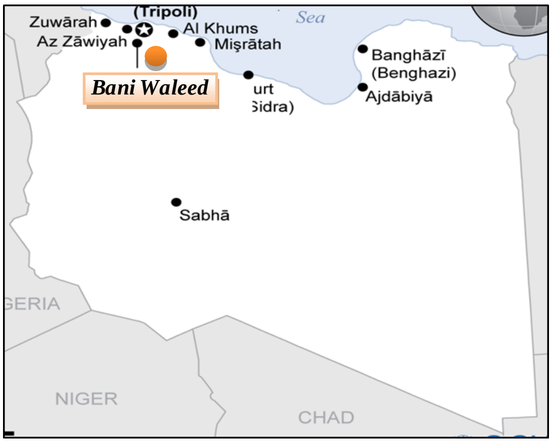

Fig. 1: Bani Waleed Location

Fig. 1a: Tagrafeet location

Fig. 1b: City Centre location.

Fig. 1c: Sakia Camp.

2.2 Sample Collection and Preparation

Nine samples were taken from the three different sites, and the soil samples were determined by using a portable Global Positioning System (GPS). The samples were taken 10 cm below the surface, placed in coded polythene bags, and sent to the Environmental Studies radiation laboratory at Alexandria University's Institute of Graduate Studies and Research (IGSR), where a high gamma spectrometry (HPG) detector was employed to evaluate the radionuclide activity concentration. The samples were air dried then, weighed using an electronic balance, and thereafter drained in a 110 °C oven. The samples were reduced to a fine powder and sieved through a mesh with just a 2 mm pore size. The ^{226}Ra and ^{232}Th short-lived daughter radionuclides were then properly sealed and stored for a month to achieve secular equilibrium with their long-lived parent radionuclides.

2.3 Gamma-ray spectra measurements.

The γ -ray spectra of the soil samples were evaluated using a high purity vertical HPGe detector (p-type with a relative efficiency of 25% and peak to Compton ratio of 54:1). The detector's energy resolution (FWHM) for the 1332 keV ^{60}Co γ-ray line source was 1.9 keV. The Genie-2000 analysis software, version 3.0, was used with the detector in conjunction with the Canberra data acquisition system to perform peak area determination, background subtraction, as well as γ-ray energy and radionuclide identification. A lead cylinder measuring 10 cm in thickness that was internally lined with a copper cylinder measuring 2 mm in thickness served as a shield for the HPGe detector. For counting during an accumulation time of 14400s, the Sample containers were placed one at a time on top of the detector (just below the shield). For back scattering and background radiation, all measurements were adjusted. Based on the energy of its γ-ray line, which is 1460.8 keV, the activity of ^{40}K has been calculated. The specific activity of ^{232}Th has been calculated using γ-ray lines of energies 338.4 keV and the 911.2 from ^{228}Ac, the 727.3 keV from ^{212}Bi, and the 583.2 keV from ^{208}Tl decay products. The activities of the decay products ^{214}Pb and ^{214}Bi were taken to represent ^{226}Ra using the γ-ray lines of energies 295.2 keV and 351.9 keV from ^{214}P [8]. The γ-ray spectra of the samples were measured at The Environmental studies. Department, Institute of Graduate studies and Research, Alexandria University, Egypt.

3.0 Calculations of activities, hazard indices and dose parameters

The activity concentrations of ^{226}Ra for ^{238}U, ^{232}Th, and ^{40}K radionuclides were represented in the calculations in this section by the symbols A_{Ra}, A_{Th}, and A_K, respectively.

3.1. activity concentration (A) in (Bq kg^{-1})

For the radionuclides ^{226}Ra, ^{343}Th, and ^{40}K, the activity concentration Ai of any taken γ-ray line to represent this parameter has been calculated using the relation [9].

$$A_i(Bq\,kg^{-1}) = \frac{C_i}{\varepsilon(E) \times t \times m} \qquad (1)$$

Where *Ci* is the net peak area of the γ-ray line at energy E after subtracting the background, (E) is the detector efficiency of such a γ-ray line, *t* is the measurement time in seconds, and *m* is the sample mass in kg. For ^{226}Ra, ^{232}Th, and ^{40}K, the globally recognized criteria of A are 35, 30, and 400 Bqkg^{-1}, respectively.

3.2 Annual effective dose equivalent (AEDE)

With an outdoor occupancy factor of 0.2 and an indoor occupancy factor of 0.8, the conversion factor (0.7 SvGy^{-1}) from absorbed dose rate in air in nGyh^{-1} to effective dose rate in mSvyr^{-1} is used to estimate the AEDE. The following equation was used to determine the AEDE (Indoor and Outdoor) . [2].

$$AEDA(Indoor)(mSv^{-1}) = D_{air}(nGy\,h^{-1}) \times 8766h \times 0.8 \times 0.7Gy^{-1} \times 10^{-6} \qquad (2)$$

$$AEDA(outdoor)(mSv^{-1}) = D_{air}(nGy\,h^{-1}) \times 8766h \times 0.2 \times 0.7Gy^{-1} \times 10^{-6} \qquad (3)$$

These metrics assess the likelihood of both stochastic and deterministic effects in irradiated people. The annual effective dose equivalent should not exceed 0.48 $mSvyr^{-1}$, and the total annual effective dose equivalent (indoors and outdoors) should not exceed 1 $mSvyr^{-1}$ [2].

3.3 Excess Lifetime Cancer Risk (ELCR):

As a result, the in-situ measurement processing can determine the corresponding annual equivalent dose, taking into account both the exposure level and the risk of developing cancer in the future. [10[, [11], [12]. used the mathematical relationship represented by the following equation to calculate the ELCR rate in $mSvy^{-1}$.

$$ELCR = (AEDE \times DL \times RF \quad (4)$$

Where RF is the risk factor (Sv), or the likelihood of dying from cancer per Sievert, and DL is the average life expectancy (70 years) for the general population, the [13]. Used RF = 0.05 for stochastic effects.

Therefore, we use the equations (5, 6) below to evaluate the Indoor and Outdoor ELCR.

$$ELCR_{OUTDOOR} = (E_{OUT} \times DL \times RF \quad (5)$$

$$ELCR_{INDOOR} = (E_{IN} \times DL \times RF \quad (6)$$

3.4 Effective Dose to Different Body Organs (D_{organ}).

The effective dose to the organ (D_{organ}) is a measure of the amount of radiation absorbed by the various organs and tissues of the body. Equation (7) is used to calculate the (D_{organ}) of the body due to inhalation [10].

$$D_{organ}(mSvy^{-1}) = AEDE_M \times F \quad (7)$$

F is the conversion factor of organ dose from air dose, and $AEDE_M$ is the mean annual effective dose equivalent (indoor and outdoor). The F values for the lungs, ovaries, bone marrow, testes, kidney, liver, and entire body, according to [14]. are 0.64, 0.58, 0.69, 0.82, 0.62, 0.46, and 0.68.

4.0 Result and Discussion:

The sampling points shown in the table (1)) below were utilized to determine the activity concentrations of the three naturally occurring radionuclides ^{226}Ra, ^{232}Th, and ^{40}K in the soil throughout the study area. The activity concentration values of ^{226}Ra varied from 22.01 ±0.085 to 86.53 ±0.155 $Bqkg^{-1}$, with an overall mean value of 50.46 ±0.118 $Bqkg^{-1}$ exceeding the permissible world value of 35 $Bqkg^{-1}$ while the activity concentration values of ^{232}Th ranged from 11.46 ±0.056 to 61.84 ±0.131 $Bqkg^{-1}$ and the mean average value is 31.72. The ^{40}K ranged between 381 ±0.325 and 707.4 $Bqkg^{-1}$, with an overall average value of 477.92 ±0.364 $Bqkg^{-1}$. Samples from B2 in City Centre had the highest average concentration of ^{40}K, while B3 in City Centre had the lowest value.

The annual effective dose equivalent (AEDE) were calculated for the three sites in Bani Waleed City and found that the values ranges from 0.028, 0.112 and 0.140 $mSvy^{-1}$ to 0.118, 0.474 and 0.592 $mSvy^{-1}$ for $AEDE_{out}$, $AEDE_{in}$ and $AEDE_T$ respectively. The mean values are 0.077, 0.310 and 0.387 $mSvy^{-1}$ respectively, All the average values are lower than that of the world average of (1.0 $mSvy^{-1}$).

Tables (2)), shows the ELCR for the three zones, a comparison with the global average as shown in Fig.2. The outdoor ELCR ranges from 0.10 x 10^{-3} to 0.41 x 10^{-3}, with a mean of 0.0725 x10^{-3}, which is below the global average of 0.29 x 10^{-3} [11]. According to a summary of the ELCR (Table (2)), the indoor ELCR ranges from 0.30 x 10^{-3} to 1.66 x 10^{-3} with a mean value of 0.27 x 10^{-3} as shown in Fig.3. These low excess lifetime cancer risk levels imply that there is a low likelihood that residents will develop cancer.. The total excess life cancer risk ($ELCR_T$) was also calculated using equation (4) and the results were displayed in Table (2)) and Fig.4. The $ELCR_T$ ranged from 0.49 x 10^{-3} to 0.207 x 10^{-3} with a mean value of 1.35 x 10^{-3}, exceeding the global average of 0.29 x 10^{-3}. With an average range of 0.95 10^{-3}, the safe range for ELCR is between 0.70 ×10^{-3} and 1.33 10^{-3}. [15], [16].

Table 1. The Radioactivity Concentrations of ^{226}Ra, ^{228}AC and ^{40}K ($BqKg^{-1}$) in the Soil Samples from three Locations in the City of Bani Waleed

Sites	Sample No.	^{226}Ra	^{228}AC	^{40}K
Tagrafeet	A1	34.32 ± 0.097	29.23 ± 0.090	570.3 ± 0.398
	A2	40.39 ± 0.105	21.63 ± 0.077	511.4 ± 0.376
	A3	62.49 ± 0.131	37.90 ± 0.102	408.2 ± 0.336
City Center	B1	30.46 ± 0.091	11.46 ± 0.056	51.99 ± 0.120
	B2	59.16 ± 0.128	61.84 ± 0.131	707.4 ± 0.443
	B3	45.51 ± 0.112	19.95 ± 0.074	381.2 ± 0.325
Sakia	C1	69.3 ± 0.138	29.54 ± 0.090	480.9 ± 0.365
	C2	26.01 ± 0.085	40.84 ± 0.106	640.7 ± 0.421
	C3	86.53 ± 0.155	33.11 ± 0.095	549.2 ± 0.390
Min		**26.01 ± 0.085**	**11.46 ± 0.056**	**381.2 ± 0.325**
Max		**86.53 ± 0.155**	**61.84 ± 0.131**	**707.4 ± 0.443**
Mean Value		**50.46 ± 0.118**	**31.72 ± 0.093**	**477.92 ± 0.364**
World average value		**35**	**30**	**400**

Table 2. The absorbed dose rate (D_R), the outdoor ($AEDE_{out}$) and indoor ($AEDE_{in}$) annual effective dose equivalent, the total effective dose equivalent($AEDE_T$), the total excess life cancer risk (ELCR), indoor ($ELCR_{in}$) and outdoor ($ELCR_{out}$) for the soil samples collected from Bani Walleed city –Libya.

Sites	Sample ID	DR ($nGYh^1$)	$AEDE_{out}$ ($mSvy^{-1}$)	$AEDE_{in}$ ($mSvy^{-1}$)	$AEDE_T$ ($mSvy^{-1}$)	$ELCR_{in}$ $mSv\ yr^{-1}$	$ELCR_{out}$ $mSv\ yr^{-1}$	ELCR $mSv\ yr^{-1}$
Tagrafeet	A1	58.53	0.072	0.287	0.359	0.00100	0.00025	0.00126
	A2	53.56	0.066	0.263	0.329	0.00092	0.00023	0.00115
	A3	69.33	0.085	0.340	0.425	0.00119	0.00030	0.00149
City Center	B1	22.83	0.028	0.112	0.140	0.00039	0.00010	0.00049
	B2	96.62	0.118	0.474	0.592	0.00166	0.00041	0.00207
	B3	49.03	0.060	0.241	0.301	0.00084	0.00021	0.00105
Sakia	C1	69.83	0.086	0.343	0.429	0.00120	0.00030	0.00150
	C2	65.69	0.081	0.322	0.403	0.00113	0.00028	0.00141
	C3	82.48	0.101	0.405	0.506	0.00142	0.00035	0.00177
Min		**22.83**	**0.028**	**0.112**	**0.140**	**0.00039**	**0.00010**	**0.00049**
Max		**96.62**	**0.118**	**0.474**	**0.592**	**0.00166**	**0.00041**	**0.00207**
Mean value		**63.09**	**0.077**	**0.310**	**0.387**	**0.00027**	**0.0000725**	**0.00135**
World av. value		**60**	**0.07**	**0.50**	**1.0**			**0.29 × 10^{-3}**

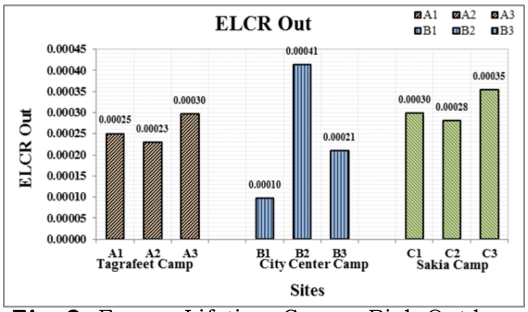

Fig. 2: Excess Lifetime Cancer Risk Outdoor ($ELCR_{out}$) in the Study Area.

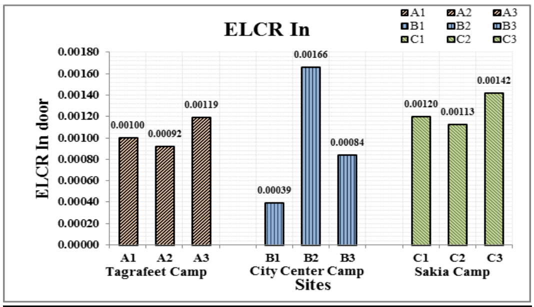

Fig. 3: Excess Lifetime Cancer Risk Indoor ($ELCR_{in}$) in the Study Area.

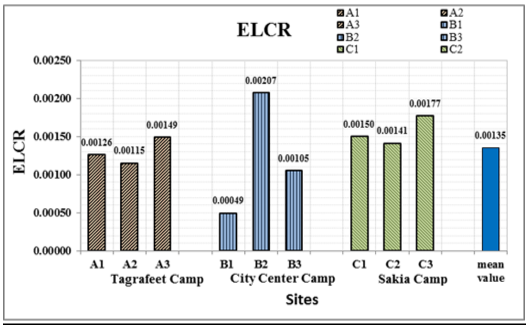

Fig. 4: Total Excess Lifetime Cancer Risk ($ELCR_T$) in the Study Area.

Table (3)) show the estimated D_{organ} values for radiation exposure and inhalation in the lungs, ovaries, bone marrow, testes, kidney, liver, and entire body in the selected area. Fig.5 shows the variation of D_{organ} to the different organs. These results are all below the tolerable international limits of 1.0 mSv^{-1}, indicating that the radiation levels in the study area do not pose a health risk. [10], [17], [18]. The results show that the whole body have the highest sensitivity to radiation (0.46) while the liver have the lowest sensitivity to radiation, respectively (0.141).

Table 2. Mean Annual Effective Dose Equivalent ($AEDE_m$) and Effective Dose rate (D_{organ}) to different body organs and tissues in the study area.

Sites	$AEDE_m$ ($mSvy^{-1}$)	Lungs	Ovaries	Bone marrow	Testes	Kidney	Liver	Whole Body
Tagrafeet Camp	0. 371	0.237	0.215	0.256	0.304	0.230	0.170	0.252
City Center Camp	0.344	0.220	0.200	0.238	0.282	0.213	0.158	0.234
Sakia Camp	0.445	0.285	0.258	0.307	0.365	0.276	0.205	0.303
Mean value	**0.387**	**0.196**	**0.178**	**0.212**	**0.252**	**0.190**	**0.141**	**0.46**
World Mean value	**1.0**	**0.64**	**0.58**	**0.69**	**0.82**	**0.62**	**0.46**	**0.68**

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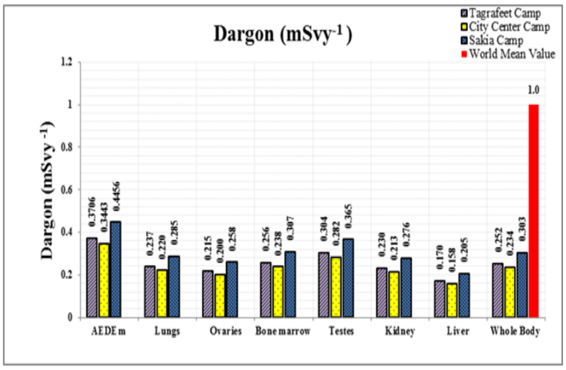

Fig. 5: Effective Dose Rate (D_{organ}) to Different Body Organs and Tissues in the Study Area.

5.0 Conclusion sand recommendation

Nine soil samples from three sites in Bani Waleed have been analyzed using hyper-pure germanium (HPGe) γ-ray spectrometry. The values of activity concentration of ^{226}Ra, ^{232}Th and ^{40}K were excess of the permissible Global value 35, 30 and 400 mSvyr^{-1} respectively, and The $AEDE_T$, (outdoor and indoor) equivalent dose rate results were all below the 1.0 mSv yr^{-1}. The values of the total excess Life Cancer Risk $ELCR_T$, (outdoor and indoor) for the three zones were comparison with the global average and are below the world permissible value.

The D_{organ} values for radiation exposure and inhalation in the lungs, ovaries, bone marrow, testes, kidney, liver, and entire body in the selected area are all below the tolerable international limits of 1.0 mSv.

Which further indicates that the radiation levels of the studied area do not pose immediate health effect on residents of the city.

المقدمة:

في ظل ظروف محددة ، يمكن أن تصل المواد المشعة الطبيعية ^{226}Ra و ^{232}Th و ^{40}K إلى مستويات إشعاعية خطيرة. ونتيجة لذلك ، فإن البحث عن مستويات النشاط الإشعاعي الطبيعي في التربة مطلوب لتقدير الجرعة للسكان ، وتحليل المخاطر الصحية ، وإنشاء خط أساس للتغييرات المستقبلية المحتملة التي يسببها النشاط البشري. تم استخدام مطياف أشعة جاما الجرمانيوم شديد النقاء (HPGe) لفحص ثلاثة مواقع في مدينة بني وليد ، ليبيا ، من أجل تحديد المخاطر الصحية الإشعاعية ، ومخاطر الإصابة بالسرطان على مدى الحياة ، والجرعة الفعالة لأعضاء الجسم المختلفة المرتبطة بالاستخدام. من التربة. جمعت تسع عينات من كل موقع من المواقع الثلاثة (تاقرفت ، الساقية ، ووسط المدينة) على عمق عشرة سم ، وتم قياسها واستخدام كاشف HPGe ، وقورنت النتائج بالقيمة العالمية المسموح بها. وكانت إجمالي عدد حالات الإصابة بالسرطان على مدى العمر ، سواء في الداخل أو في الهواء الطلق أقل من القيمة العالمية المسموح بها ، وكانت نتائج جميع أعضاء الجسم المختلفة أقل من الحدود الدولية المقبولة البالغة 1.0 ملي سيفرت في السنة ، مما يشير إلى أن مستويات الإشعاع في منطقة الدراسة هي آمنة ولا تشكل خطرا على صحة السكان المحليين. يمكن أن تكون نتائج هذا البحث بمثابة بيانات أساسية إشعاعية مهمة للتحقيقات الوبائية القادمة وبرامج المقاضاة والرصد البيئي.

الكلمات الرئيسية:

بني وليد، تاقرفت، الساقية، وسط المدينة، مطياف أشعة جاما الجرمانيوم شديد النقاء

Abbreviations	
HPGe	Highper-Pure Germanium
^{226}Ra	Radium 226
^{232}Th	Thorium 232
^{40}K	Potassium 40
FWHM	Full width high measurement
Γ-Ray	Gamma Ray
mSvGy^{-1}	Mill Sievert Gray per year
nGyh^{-1}	Nano gray per hour
DR	Dose Rate
$AEDE_T$	Total Annul effective dose Equivalent
$AEDE_{in}$	Annul effective dose Equivalent indoor
$AEDE_{Out}$	Annul effective dose Equivalent outdoor.
$AEDE_M$	Mean Annul effective dose Equivalent
$ELCR_T$	Total Excess Life Cancer Risk.
$ELCR_{IN}$	Excess Life Cancer Risk indoor.
$ELCR_{OUT}$	Excess Life Cancer Risk outdoor

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