Scholars Journal of Physics, Mathematics and Statistics
OPEN ACCESS
Abbreviated Key Title: Sch J Phys Math Stat
ISSN 2393-8056 (Print) | ISSN 2393-8064 (Online)
Journal homepage: https://saspublishers.com

Natural Radioactivity Levels and Elements Concentrations in Agricultural Soil and Underground Water

Roba Badghish[1*], Dr. Safia Hamidalddin[2]

[1]Department of Physics, Faculty of Science, Jeddah University, Saudi Arabia
[2]Department of Physics, Faculty of Science, Jeddah University, Saudi Arabia

DOI: 10.36347/sjpms.2022.v09i04.001 | **Received:** 19.03.2022 | **Accepted:** 23.04.2022 | **Published:** 09.05.2022

***Corresponding author:** Roba Badghish
Department of Physics, Faculty of Science, Jeddah University, Saudi Arabia

Abstract **Original Research Article**

Concentrations of NORM nuclides (^{226}Ra, ^{232}Th and ^{40} K), essential and toxic elements were measured in (10 agricultural soil and 10 irrigation water) samples. The samples were collected randomly from 6 locations, within the plantation area from Makkah region Saudi Arabia. For activity measurements, gamma-ray spectrometry (HPGe) detector was used. In chemical analysis, Inductively Coupled Plasma Optical Emission (ICP-OES) and Mas Emission (ICP-MS) Spectrometry were used to measure the concentrations of soil and water respectively. Soil activity concentrations are (18.11, 16.12, 1603.73) Bq/Kg, in water are (1.57, 0.58, 118.44) Bq/l.Radium equivalent activity (Ra_{eq}), hazard indices (H_{ex} and H_{in}) mean values in soil and water are less than the limits (370Bq/ Kg and<1). Mean values of total absorbed dose rate (D_R) are greater than 57 (nGy/h) in soil, and less than 71.1 (nGy/h) in water. Annual effective doses (D_{eff}) mean values are greater than 0.07 mSv/y in soil and less than permitted limit 0.41 mSv/y. ICP-OES and ICP-MS were used to measure the concentrations of elements in soil and in water respectively. Esential elements concentrations (Al, Ca, Fe, K, Mg, Mn and Na) in soil are (7.738, 4.061, 5.691, 1.288, 2.778, 0.059, 1.683) higher than the guideline value. Toxic elements (As, Cd, Cr, Cu, Hg, Ni, Pb, Se and Zn) are within global values except Cr and Ni, they are excesses the permissible limits. Essential elements (Ca, Mg, Na, K, Fe) concentrations of water (155.83, 51.34, 343.6, 10.18, N D) are higher than the guideline values. Trace element (Cu, Cr, Hg, Mn, Ni,Se, Zn) concentrations are (1.66, 2.64, 0.03, 0.19, 4.95, 9.18, 58.67) are within permissible limits and guideline, except elements (Al, As, Cd, and Pb) are classified as a toxic. Effect of irrigation water containing heavy metals may be a reason for increasing the concentrations of heavy metals in agricultural soil.

Keywords: NORM nuclides, Gamma-ray spectrometry (HPGe), Chemical Analysis (ICP-OES and ICP-MS), Agricultural soil and Irrigation water.

1-INTRODUCTION

Natural and artificial sources of radioactivity can be found in the environment. Natural radiation exposure accounts for the majority of total radiation exposure in the environment (Kohn, 1989). The majority of radiation is made up of gamma rays, which are produced by the radioactive decay of unstable nuclei (226Ra, 232Th, and 40K). Natural radionuclides are found in small quantities in all foods, they are transported from soil and water to crops to fish in their various environments. the concentrations of radionuclides from these natural radionuclides can rise depending on the type and geology of the soil, agricultural fertilizers, and climate (UNSCEAR, 2000). Human receive roughly 87% of natural radiation, it is vital to calculate these doses to control the detrimental effects of radiation ("Eval. Guidel. Expo. to Technol. Enhanc. Nat. Occur. Radioact. Mater.," 1999). The study of natural radiation of these radionuclides in agricultural environmental samples is crucial for human health, as his food may be farmed in radioactive soil or irrigated with radioactive water, Human have been exposed to these radionuclides in two ways since the beginning of time: through direct food ingestion and air inhalation. As a result, dosage estimation is critical for radiation protection databases and geophysics research (Aswood *et al.*, 2017) The purpose of this study is to measure the natural radioactivity content, annual effective radiation doses, external radiation hazard indices, and determent of element concentration in the agricultural areas of Makkah.

Citation: Roba Badghish & Safia Hamidalddin. Natural Radioactivity Levels and Elements Concentrations in Agricultural Soil and Underground Water. Sch J Phys Math Stat, 2022 May 9(4): 33-40.

2- METHODOLOGY

2.1 Sampling and Samples Preparation

In Figure 1, thirty samples of agricultural environmental samples were collected from Saudi Arabia's western region (MAKKAH).

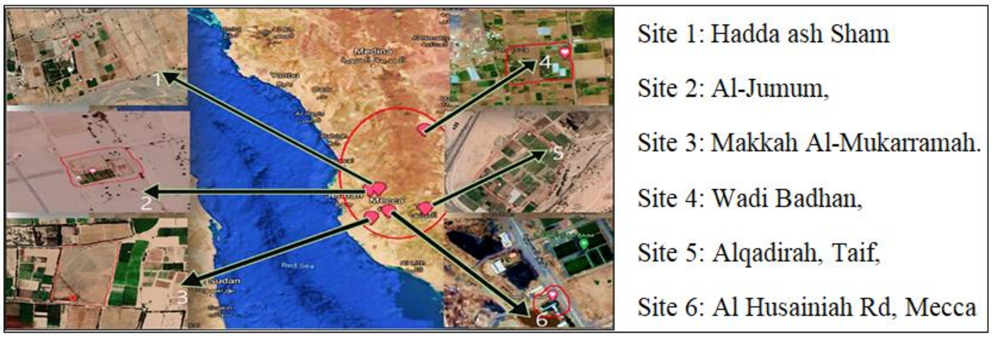

Fig 1: Location map of the studied area samples

Agricultural soil and irrigation water from the same agricultural environment were collected with a trowel and placed in a polyethylene bag. The soil samples were gathered at a depth of 10 cm and dried in the air for five days to confirm that they were completely dry and ready to grind. The dirt was processed in a specialized laboratory. To avoid self-attenuation within the samples, soil samples were sieved with a 1 mm sieve to obtain a uniform powder (States & Radiation, 2019).(Ibikunle et al., 2019).Soil and water samples were filled in cylindrical plastic Marinelli containers of the same size, the weight of each sample is recorded and the containers are sealed with a thick adhesive tape to prevent leakage of ^{222}Rn. Samples were stored for not less than two months to allow the restoration of the radiative balance between ^{226}Ra and its progenies (International Atomic Energy Agency, 2019) (Matter, 2019).

2.2 Measurements techniques:

2.2.1 Gamma-ray spectrometry system:

The activity of natural radionuclides in agricultural environment (soil and water) samples were evaluated using an (HPGe) detector with (2.0) Kev resolution at 1332.5 keV of Co-60 and (25%) relative efficiency. Genie 2000 software was used for data analysis and display. The system was calibrated for absolute efficiency and energy. The lowest limits of detection for 226Ra, 232Th, and 40K were (0.104, 0.019, and 0.761) respectively. The measurements were taken for a total of 43,200 seconds.

2.2.2 Inductively coupled plasma-optical emission spectroscopy for soil:

ICP-OES is the technique of choice for many applications, including those in the environmental, geological, and food safety arenas. ICP-OES device analyses the rock samples and soil samples for trace elements, after converting the soil samples into solutions, digesting with appropriate acids and entering into the device in the form of solutions. This device depends on the analysis to read the emission intensity of the wavelength of the element to be analysed**.**

2.2.3 Inductively coupled plasma- mass spectrometry for water:

Inductively Coupled Plasma-Mass Spectrometry is a powerful technique of mass spectrometry technology that is able to analysis several of elements of the sample due to high sensitivity and capable of distinguishing between other isotopic for ions of choice. (Caballero, 2003). This device analyses water samples for trace elements by entering the sample directly into the device, for reading the mass of the elements to be analysed.

2.3 Calculations

The energies used for the calculation's concentrations:

(a) ^{214}Pb (295.09 and 351.87 KeV), ^{214}Bi (609.31, 1120.27 and 1764.49 KeV) for ^{226}Ra.

(b) ^{228}Ac (338.42, 911.16 and 968.97 KeV), ^{212}Pb (238.58 KeV), ^{212}Bi (727.25 KeV), ^{208}Tl (583.1 and 860.4 KeV) for ^{232}Th.

(c) ^{40}K (1460.80 KeV) for potassium.

The activity concentrations in soil Bq/kg and water Bq/l samples were measured using following formula (Mugren, 2015):

$$\boldsymbol{A_s(Bq.Kg^{-1})} = \frac{\mathbf{C_a}}{\boldsymbol{\varepsilon}\mathbf{P_r M_s}} \text{ ……………… (1)}$$

Where: c_a was the net gamma counting rate (per second), ε detector absolute efficiency of the specific γ-ray, Pr the transition probability of Gamma-decay and Ms the mass of the sample (kg). Radium equivalent (Ra_{eq}) was calculated by equation (2) (Uosif *et al.*, 2019)

$$\mathbf{Ra_{eq}} = \mathbf{A_{226Ra}} + \mathbf{1.43} \times \mathbf{A_{232Th}} + \mathbf{0.077} \times \mathbf{A_{40k}} \text{ …………….. (2)}$$

Where: $\boldsymbol{A_{226Ra}}$, $\boldsymbol{A_{232Th}}$ and $\boldsymbol{A_{40k}}$ were specific activities $(Bq./Kg)$ of ^{226}Ra, ^{232}Th, and ^{40}K respectively. The absorbed dose rate (nGy/h) 1m above the ground due to the activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K (Bq/ kg) dry Weight was calculated using the equation(3) (UNSCEAR, 2000):

$$\mathbf{D\ (nGy/h) = 0.462CRa + 0.604CTh + 0.0417CK} \ldots\ldots\ldots\ldots\ldots (3)$$

Where: CRa, CTh, and CK are the specific activities concentrations of ^{226}Ra, ^{232}Th and ^{40}K in (Bq/Kg) dry weight respectively. The annual indoor and outdoor effective doses in units of mSv/y were calculated using conversion coefficient factors (0.7 Sv.G/y to convert D nGy/h to D mSv/y), (0.8 for indoor, 0.2for outdoor) and (10^{-6} is the conversion factor between nano and milli) (UNSCEAR, 2000) in equations (4, 5):

$$\mathbf{D\ (mS\ v/y) = D\ (nGy/h) \times 8760\ h/y \times 0.8 \times 0.7\ (Sv.G/y\ ) \times 10^{-6}} \ldots\ldots\ldots\ldots\ldots (4)$$

$$\mathbf{D\ (mSv/y) = D\ (nGy/h) \times 8760\ h/y \times 0.2 \times 0.7\ (Sv.G/y) \times 10^{-6}} \ldots\ldots\ldots\ldots (5)$$

D (mSv/y) due to ingestion of water were calculated from equation (4) and D (mSv/y) for soil were calculated from equation (5). The external and internal hazard index (H_{ex}) and (H_{in}) were calculated by following equations (UNSCEAR (2000):

$$\mathbf{H_{in}} = \frac{\mathbf{A_{Ra}}}{\mathbf{185}} + \frac{\mathbf{A_{Th}}}{\mathbf{259}} + \frac{\mathbf{A_{k}}}{\mathbf{4810}} \leq 1 \ldots\ldots\ldots (6)$$

$$\mathbf{H_{ex}} = \frac{\mathbf{A_{Ra}}}{\mathbf{370}} + \frac{\mathbf{A_{Th}}}{\mathbf{259}} + \frac{\mathbf{A_{k}}}{\mathbf{4810}} \leq 1 \ldots\ldots\ldots\ldots\ldots (7)$$

3.1 Activity Concentrations and Radiation Hazards

The activity concentration of natural radionuclides present in the soil and water samples of the selected area measured by direct gamma-ray spectrometry is given in Table (3.1). The results for natural radionuclides are calculated in Bq/kg on a dry weight basis for soil samples, while it calculated in Bq/l for water samples.

Table (3.1): Activity concentrations of ^{226}Ra, ^{232}Th, and ^{40}K in Bq/Kg for soil and Bq/l for water

Samples Descriptions			**Concentrations in Bq/Kg for soil and Bq/L for water**		
Sa. No.	**Sa codes**	**Sa Names**	**^{226}Ra**	**^{232}Th**	**^{40}K**
1	**S1**	**Soil**	**14.46 ±1.05**	**12.72±1.42**	**1218.92 ±12.58**
	W1	**Water**	**1.00 ±0.45**	**1.00 ±0.40**	**117.13 ±4.98**
2	**S2**	**Soil**	**14.46 ±1.05**	**12.72±1.42**	**1218.92 ±12.58**
	W2	**Water**	**1.00 ±0.45**	**1.00 ±0.40**	**117.13 ±4.98**
3	**S3**	**Soil**	**16.52 ±0.81**	**13.97±1.74**	**2244.38 ±16.77**
	W3	**Water**	**1.76 ±0.84**	**0.14 ±0.15**	**145.25 ±5.37**
4	**S4**	**Soil**	**20.19 ±0.97**	**21.63±1.90**	**2180.95±16.44**
	W4	**Water**	**0.75 ±0.19**	**N D**	**105.29 ±4.70**
5	**S5**	**Soil**	**24.47 ±1.77**	**28.13±2.33**	**2772.97 ±18.39**
	W5	**Water**	**0.62 ±0.19**	**0.92 ±0.34**	**107.83 ±4.64**
6	**S6**	**Soil**	**18.12 ±1.21**	**11.83±1.34**	**1259.09 ±13.08**
	W6	**Water**	**0.43 ±0.19**	**ND**	**117.55 ± 4.84**
7	**S7**	**Soil**	**18.12 ±1.21**	**11.83±1.34**	**1259.09 ±13.08**
	W7	**Water**	**0.43 ±0.19**	**ND**	**117.55 ± 4.84**
8	**S8**	**Soil**	**21.57 ±1.32**	**20.95±1.25**	**1916.66 ±15.39**
	W8	**Water**	**1.57 ±1.06**	**0.45 ±0.34**	**134.47 ±5.14**
9	**S9**	**Soil**	**15.06 ±1.10**	**13.42 ±1.39**	**1032.86 ±11.46**
	W9	**Water**	**4.16 ±1.64**	**0.32 ± 0.39**	**113.96 ±4.78**
10	**S10**	**Soil**	**18.19 ±1.12**	**14.03 ±2.08**	**933.48 ± 11.35**
	W10	**Water**	**4.07 ±1.27**	**2.06 ±0.92**	**108.25 ± 4.62**
Range		**S**	**14.46 - 24.47**	**11.83 - 28.13**	**933.48 -2772.97**
		W	**0.43 - 4.16**	**0.14 - 2.06**	**105.29 -145.25**
Mean		**S**	**18.11**	**16.12**	**1603.73**
		W	**1.57**	**0.58**	**118.44**
(UNSCEAR, 2008)		**S**	**33**	**45**	**420**
(WHO, 2008)		**W**	**1**	**0.1**	**10**

ND: Not Detection S: soil, W: water

^{40}K was present in a very significant amount in soil. ^{40}K activity concentrations ranged from 933.48 to 2772.97 Bq/kg with a mean value of 1603.73 Bq/kg. In water, ^{40}K were found to be 105.29 to 145.25 Bq/l with a mean value of 118.44 Bq/l, these values are much higher than the world mean (420 Bq/kg) (UNSCEAR 2008) (Nations *et al.*, 2008) in soil and (10 Bq/l) (WHO 2008) in water. ^{226}Ra activities ranged from 14.46 to 24.47 Bq/kg with a mean value of 18.11 Bq/kg, ^{232}Th were ranged from 11.83 to 28.13 Bq/kg with a mean value 16.12 Bq/kg. These results in soil for ^{226}Ra and ^{232}Th were found lower than the world average values

(33 Bq/kg) and (45Bq/kg) respectively (UNSCEAR 2008). ^{226}Ra for water samples activities ranged from 0.43 to 4.16 Bq/l with a mean value of 1.57 Bq/l , ^{232}Th series were activities ranged from 0.14 to 2.06 Bq/l with a mean value 0.58 Bq/l. ^{226}Ra and ^{232}Th results have been found higher than the world mean values (1 and 0.1) Bq/l (WHO 2008). Table (3.2) gives the radium equivalent (Ra_{eq}), the dose rate (D_R), the annual effective dose (D_{eff}), the external and internal hazard indices (H_{ex} and H_{in}). For soil (Bq/kg), and water (Bq/l) samples.

Table (3.2): The radium equivalent (Ra_{eq}), the dose rate (D_r), the annual effected dose (D_{eff}) and Hazard indices (H_{in}, H_{ex})

Sa. No.	Sa. codes	Sample Name	Ra_{eq} (Bq/kg) or (Bq/ l)	D_R (nGy/h)	D_{eff} (mSv/y)	H_{in}	H_{ex}
1	S1	Soil	126.50	65.192	0.399	0.380	0.341
	W1	water	2.43	5.950	0.036	0.033	0.030
2	S2	Soil	126.50	65.192	0.399	0.380	0.341
	W2	Water	2.43	5.950	0.036	0.033	0.030
3	S3	Soil	209.31	109.66	0.672	0.609	0.565
	W3	Water	1.96	6.954	0.042	0.040	0.035
4	S4	Soil	219.05	113.33	0.694	0.646	0.591
	W4	Water	0.75	4.737	0.029	0.025	0.023
5	S5	Soil	278.21	143.92	0.882	0.817	0.751
	W5	Water	1.93	5.338	0.032	0.029	0.027
6	S6	Soil	131.98	68.020	0.417	0.405	0.356
	W6	Water	0.43	5.100	0.031	0.026	0.025
7	S7	Soil	131.98	68.020	0.417	0.405	0.356
	W7	Water	0.43	5.100	0.031	0.026	0.025
8	S8	Soil	199.11	102.54	0.628	0.595	0.537
	W8	Water	2.21	6.604	0.040	0.038	0.033
9	S9	Soil	34.25	58.133	0.356	0.347	0.307
	W9	Water	4.61	6.867	0.042	0.047	0.036
10	S10	Soil	38.25	55.804	0.342	0.346	0.297
	W10	Water	7.01	7.638	0.046	0.052	0.041
Range		S	34.25 - 278.21	55.804-143.92	0.342 - 0.882	0.346 -0.817	0.297 -0.751
		W	0.43 -7.01	4.737 - 7.638	0.029 - 0.046	0.025 -0.052	0.023 -0.041
Mean		S	149.51	84.981	0.520	0.493	0.444
		W	2.41	6.023	0.0365	0.0349	0.0305
UNSCEAR (2000)		S	370	57	0.07	< 1	< 1
UNSCEAR (2000)		W	370	71.08	0.41	< 1	< 1

Ra_{eq} values are ranged from 34.25 to 278.21 Bq/kg with mean of 149.51 Bq/kg in soi1. In water, they are ranged from 0.43 to 7.01Bq/l with mean value 2.41Bq/l, mean values are lower than the recommended maximum value of 370 by (UNSCEAR, 2000). In soil Samples, D_R values are ranged from 55.804 to143.92 nGy/h with mean value of 84.981 nGy /h, in water, D_R are ranged from 4.737 to 7.638 nGy/h with mean 6.023 nGy/h. As compared with the worlds mean value, D_R nGy/h in soil is higher than 57 nGy/h, in water, D_R is lower than permissible limits 71.08 nGy/h (UNSCEAR, 2000).D_{eff} values for soil are ranged from 0.342 to 0.882 mSv/y with mean value 0.520 mSv/y, wich is higher than the recommended 0.07 mSv/y. For water (D_{eff}) are ranged from 0.029 to 0.046 mSv/y with mean 0.0365 mSv/y which is less than the world value 0.41mSv/y (UNSCEAR, 2000) In soil, H_{in} ranged from 0.346 to 0.817 and H_{ex} ranged from 0.297 to 0.751 with an mean values 0.493 and 0.444 respectively, Also in water, H_{in} ranged from 0.025 to 0.052 and H_{ex} ranged from 0.023to 0.041 with an average values 0.0349 and 0.0305 respectively, these values agree with the world values < 1 by (UNSCEAR, 2000). The usage of fertilizers, as .well as the geological nature of the analyzed area, has resulted in an increase in the rate of absorbed dosage and effective dose in soil samples

3.2. The concentrations of elements in the samples

3.2.1ICP-OES (inductively coupled plasma- optical emission spectrometry) for Soil. Tables (3.3a and 3.3b) represent the elements concentrations of agricultural soil sampes

Table (3.3a).The concentrations of elements in agricultural soil used in the selected farms compared with different guideline

Elements		Al	Ca	Fe	K	Mg	Mn	Na
Sa No.	Units	%	%	%	%	%	%	%
	DL	0.05	0.05	0.05	0.05	0.05	0.05	0.05
1	S1	8.01	4.57	6.60	0.92	3.59	0.11	2.00
2	S2	8.01	4.57	6.60	0.92	3.59	0.11	2.00
3	S3	8.43	2.44	3.04	1.76	1.25	0.06	2.48
4	S4	7.53	2.92	3.82	2.11	1.44	0.08	1.85
5	S5	7.71	2.94	3.75	2.19	1.44	0.07	1.91
6	S6	8.51	4.58	6.81	0.92	3.44	0.09	0.85
7	S7	8.51	4.58	6.81	0.92	3.44	0.09	0.85
8	S8	6.46	2.94	3.64	1.65	1.43	0.07	1.67
9	S9	7.34	4.63	7.35	0.78	3.82	0.12	1.82
10	S10	6.87	6.44	8.49	0.71	4.34	0.15	1.40
Range		6.46-8.51	2.44-6.44	3.04-8.49	0.71-2.19	1.25-4.34	0.06-0.15	0.85-2.48
Mean		7.738	4.061	5.691	1.288	2.778	0.095	1.683
MPC		4.70^a	0.30^a	5^b	1.21^a	1.13^a	0.063^a	0.24^a

MPC: maximum permissible concentrations, a: IAEA-soil-7 reference material, b: WHO, c: Trace Elements in Soils and Plants

Table (3.3a) shows that the concentrations for all elements of (Al, Ca, Fe, K, Mg, Mn and Na) are higher than the guideline value set by IAEA-soil-7 reference material (Njinga *et al*., 2013), and WHO (Lacstusu, 1998) and (Stanojković-Sebić *et al*., 2017). These elements are essential in agricultural soils except Al and Na they are considered beneficial for improve agricultural soil (Kaur *et al*., 2016) and (Points *et al*., 2021), and they are required in specific quantities in this study, Al was detected with mean concentration of 7.738 % which is higher than guideline values 4.70%. Calcium and magnesium are also important elements. The role of calcium to support many enzyme functions. Magnesium is necessary to the photosynthetic process. There concentrations were detected 4.06, and 2.778% respectively, which there are exceeded the global values of 0.30 and 1.13% respectively. Iron is essential of synthesis chlorophyll.it was concentrations of 5.69% higher than global values of 5%. Also, potassium is essential elements, the concentration of K 1.288% was higher than permissibility 1.21%. Manganese activates some enzymes contributes to chlorophyll creation. The concentration of Mn 0.095% was higher than global limits 0.0631%. Concentration of Na 1.683% was higher the guideline values 0.24%.

Table (3.3b): The concentrations of elements in agricultural soil used in the selected farms compared with different guideline

Elements		As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Zn
S. NO.	Unit	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g
	DL	0.10	2.00	1.00	1.00	0.50	1.00	1.00	0.10	1.00
1	W1	1.58	<2	312.91	106.00	0.60	257.00	13.00	0.20	201.00
2	W2	1.58	<2	312.91	106.00	0.60	257.00	13.00	0.20	201.00
3	W3	0.75	<2	241.80	43.00	<0.5	40.00	11.00	0.20	138.00
4	W4	2.05	<2	556.38	56.00	<0.5	62.00	18.00	0.20	140.00
5	W5	2.15	<2	479.41	62.00	<0.5	62.00	10.00	0.20	168.00
6	W6	1.39	<2	251.84	124.00	<0.5	235.00	7.00	0.50	188.00
7	W7	1.39	<2	251.84	124.00	<0.5	235.00	7.00	0.50	188.00
8	W8	1.73	<2	487.78	75.00	< 0.5	59.00	11.00	0.40	189.00
9	W9	1.21	<2	374.83	136.00	0.60	254.00	8.00	0.40	199.00
10	W10	3.85	<2	309.57	131.00	0.60	264.00	8.00	0.40	170.00
Range		0.7-3.85	-	241.80-556.38	43-136	<0.-0.60	40-264	7-18	0.20-0.50	138-201
Mean		1.77	N. D	357.93	96.3	0.24	172.5	10.6	0.32	178.2
MPC		$15\text{-}20^c$	$1\text{-}5^c$	$50\text{-}200^c$	$60\text{-}150^c$	$0.5\text{-}5^c$	$20\text{-}60^c$	$20\text{-}300^c$	0.44^c	$100\text{-}300^c$

MPC: maximum permissible concentrations, c: Trace Elements in Soil samples

Table (3.3b) represents, the results show that, all elements are within global values except Cr and Ni they are excesses the permissible limits (Kabata-Pendias, 2010). These elements are classified as a toxic elements and required in very small quantities (La, 2014) Contamination with toxic and trace elements often occur when the use of chemicals enriched with elements , fertilizers, and organic amendments such as sewage, sludge and wastewater leads to widespread pollution (He *et al*., 2005). The results of this study revealed that soil samples from Wadi Badhan contained the highest level of almost all of the studied heavy metals, followed by soil samples from Hadda-ash Sham and Al-Jumum.

3.2.2 ICP-MS (inductively coupled plasma – Mass spectrometers for water samples

The inductively coupled plasma-Mass spectrometers (ICP-MS) was used to analyse and calculate the elements concentrations of the water samples. ICP-MS is suitable technique for analysing water samples to find out the concentration of elements, because this technology is more sensitive to measuring trace elements in the water *(Baralkiewicz et al.*, 2007) tables (3.4a and 3.4b) represent the concentrations of elements in irrigation water used in the selected farms compared with different guideline.

Table (3.4a): The concentrations of elements in irrigation water used in the selected farms compared with different guideline

S No.	Elements	Ca	Mg	Na	k	Fe
	Units	mg/l	mg/l	mg/l	mg/l	mg/l
	DL	0.01	0.01	0.01	0.01	0.01
1	W1	242.40	65.85	520.00	23.10	<0.01
2	W2	242.40	65.85	520.00	23.10	<0.01
3	W3	181.80	46.50	320.00	5.58	<0.01
4	W4	25.20	22.34	268.00	9.98	<0.01
5	W5	254.70	63.57	518.00	18.45	<0.01
6	W6	180.00	45.60	310.00	5.20	<0.01
7	W7	180.00	45.60	310.00	5.20	<0.01
8	W8	30.70	25.35	166.00	3.55	<0.01
9	W9	180.00	86.30	334.00	3.00	<0.01
10	W10	41.10	46.50	170.00	4.66	<0.01
Range		25.20-254.70	22.34-86.30	166-520	3-23.10	-
Mean		155.83	51.34	343.6	10.18	N. D
MPC		10-74[a]	6-40[a]	312[a]	5-10[c]	5[b]

MPC: maximum permissible concentrations, a: AGWR (2006), b: EPA (2012), c: Irrigation Water Guidelines

Table (3,4a) shows that, Ca ranged in mg/l from 25.20 to 254.70 with mean 155.83mg/l, Mg ranged in mg/l from 22.34 to 86.30 with mean 51.34 mg/l, Na ranged in mg/l from 166 to 520 with mean 343.6 mg/l, K ranged in mg/l from 3 to 23.10 with mean10.18mg/l, and Fe was not detection. Table (4.8a) shows that, the concentrations for elements of (Ca, Mg, Na and K) are higher than the guideline value set by AGWR (2006), EPA(2012) (Shoushtarian & Negahban-Azar. 2020). These elements (Ca,Mg,Na,K,Fe) are considered essential in irrigation water Guidelines (Sorghum, 2012).

Table (3.4b): the concentrations of elements in irrigation water used in the selected farms compared with different guideline

S No.	Elements	Al	As	Cd	Cr	Cu	Hg	Mn	Ni	Pb	Se	Zn
	Units	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l	µg/l
	DL	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1	W1	<0.1	2.08	<0.1	2.63	<0.1	0.15	<0.1	5.48	<0.1	8.73	117.92
2	W2	<0.1	2.08	<0.1	2.63	<0.1	0.15	<0.1	5.48	<0.1	8.73	117.92
3	W3	7.85	3.53	<0.1	0.15	2.39	<0.1	0.57	2.86	0.18	5.28	100.59
4	W4	<0.1	1.73	<0.1	0.73	1.62	<0.1	<0.1	8.11	<0.1	11.35	55.56
5	W5	<0.1	1.94	<0.1	0.84	2.02	<0.1	0.44	10.1	<0.1	18.20	135.70
6	W6	0.12	0.25	<0.1	2.51	0.20	<0.1	0.20	4.87	<0.1	9.79	11.35
7	W7	0.12	0.25	<0.1	2.51	0.20	<0.1	0.20	4.87	<0.1	9.79	11.35
8	W8	2.62	0.24	<0.1	0.61	7.53	<0.1	0.14	1.37	<0.1	1.30	14.43
9	W9	2.21	0.27	<0.1	1.36	0.21	<0.1	0.40	4.46	<0.1	12.18	1.83
10	W10	33.65	0.18	<0.1	12.44	2.45	<0.1	<0.1	1.91	0.32	6.46	20.07
Range		< 0.1 - 33.65	0.18-3.53	-	0.15 - 12.44	< 0.1 -7.53	<0.1-0.15	<0.1-0.57	1.37-10.10	<0.1-0.32	1.30-18.20	1.83-135.70
Mean		4.65	1.25	N.D	2.64	1.66	0.03	0.19	4.95	0.05	9.18	58.67
MPC		50 00[b]	100[b]	10[b]	100[b]	200[b]	0.1-2[a]	200[b]	200[b]	5000[b]	20[b]	2000[b]

MPC: maximum permissible concentrations, a: AGWR (2006), b: EPA (2012)

The results in table (3.4b) show that, the concentrations for all elements are within permissible limits of AGWR (2006) (Environment, 2006), and EPA (2012) (Crook *et al*., 2012) guideline. These elements are trace elements in the water except (Al, As, Cd, and Pb) are classified as a toxic elements (Alqahtani *et al*., 2020). It was observed that the concentrations in the water samples in order Na > Ca,> Zn> Mg> K> Se>

Ni> Al> Cr> Cu> As > Mn >Pb> Hg. The variation in elements concentration is controlled by the variation in local and regional geology, dilution due to precipitation, interactions between water and rock (Abdel-Satar *et al*., 2017). The highest values of Al found in samples W3 and W10, for As elements, samples were in W1, W2, W3, W4, and W5. Pb element has highest value observed in sample W10. The results of this study revealed that irrigation water from Alqadirah, Taif and Hadda ash Sham regions contained the highest level of almost all of the studied heavy metals followed by water samples from Al-Jumum, Wadi Badhan, and Makkah.

4. CONCLUSION

In this study, the concentrations mean of ^{226}Ra, ^{232}Th are within the suggested limit values of soil samples, but they were slightly higher in water samples. The concentrations of ^{40}K are much higher than permissible limits. Mean values of radium equivalent activity (Ra_{eq}) (soil and water) are within the worldwide limits. Hazard indices H_{ex} and H_{in} (soil and water) are in agreement with the worldwide limits. The total absorbed dose rate (D_R) in soil is more than the allowed limits, annual effective dose (D_{eff}) is less than the allowed limits. (D_R) and (D_{eff}) of water samples are lower than the recommended values (UNSCEAR, 2000). The obtained concentration values of soil metals (Al, Ca, Fe, K, Mg, Mn, Na, Cr, and Ni) are higher than the recommended values in (IAEA and WHO). Elements concentrations of water samples are within the recommended values except the (Ca, Mg, Na, and K) are found higher than recommended values of (AGWR, EPA). Elements (As, Cd, Cr, Cu, Hg, Ni, Pb, Se, Zn) results show that, all elements are within global values, except Cr and Ni, are excesses the permissible limits (Kabata-Pendias, 2010). The activity concentrations of naturally occurring radionuclides in soil samples are high due to the use of fertilizers, also one of the reasons for the existence of high ^{40}K activity in the soil is potassium-containing fertilizers. However, the excessive use of pesticides and phosphate fertilizers, and recently mining activities have increased the accumulation of heavy metals in an agricultural environment. An increase in the concentration of components in soil and water samples, whether essential or toxic, indicates that they are harmful to the plants. These results indicate to the highest doses location of farm (1) and lowest in farms (3)(6) while the other farms were slightly high than recommended does values.

Acknowledgment

The authors are indebted to the Saudi Geological Survey (SGS) for their technical help.

REFERENCES

- Abdel-Satar, A. M., Al-Khabbas, M. H., Alahmad, W. R., Yousef, W. M., Alsomadi, R. H., & Iqbal, T. (2017). Quality assessment of groundwater and agricultural soil in Hail region, Saudi Arabia. *Egyptian Journal of Aquatic Research*, *43*(1), 55–64. https://doi.org/10.1016/j.ejar.2016.12.004
- Abojassim, A. A., Hady, H. N., & Mohammed, Z. B. (2016). Natural radioactivity levels in some vegetables and fruits commonly used in Najaf Governorate, Iraq. *Journal of Bioenergy and Food Science*, *3*(3), 113–123. https://doi.org/10.18067/jbfs.v3i3.108
- Alqahtani, F. Z., Daifallah, S. Y., Alaryan, Y. F., Elkhaleefa, A. M., & Brima, E. I. (2020). Assessment of Major and Trace Elements in Drinking Groundwater in Bisha Area, Saudi Arabia. *Journal of Chemistry*, *2020*. https://doi.org/10.1155/2020/5265634
- Aswood, M. S., Jaafar, M. S., & Salih, N. (2017). Estimation of annual effective dose due to natural radioactivity in ingestion of vegetables from Cameron Highlands, Malaysia. *Environmental Technology and Innovation*, *8*, 96–102. https://doi.org/10.1016/j.eti.2017.05.004
- Baralkiewicz, D., Gramowska, H., Hanc, A., Krzyzaniak, I., & Chemistry, F. (2007). *A Comparison of ICP-OES and ICP-MS in the Determination of Elements in Lake Water*. *October*.
- Caballero, B. (2003). Encyclopedia of Food Sciences and Nutrition. *Encyclopedia of Food Sciences and Nutrition*, *1*, 6406.
- Crook, J., Ammerman, D., Okun, D., & Matthews, R. (2012). EPA Guidlines for Water Reuse. *Guidelines for Water Reuse*, *September*, 643.
- Environment, C. (2006). Atlantic Canada Wastewater Guidelines Manual for Collection ,. *Specialist*.
- Evaluation of Guidelines for Exposures to Technologically Enhanced Naturally Occurring Radioactive Materials. (1999). In *Evaluation of Guidelines for Exposures to Technologically Enhanced Naturally Occurring Radioactive Materials*. https://doi.org/10.17226/6360
- Görür, F. K., Keser, R., Akçay, N., Dizman, S., As, N., & Okumuşoğlu, N. T. (2012). Radioactivity and heavy metal concentrations in food samples from Rize, Turkey. *Journal of the Science of Food and Agriculture*, *92*(2), 307–312. https://doi.org/10.1002/jsfa.4576
- He, Z. L., Yang, X. E., & Stoffella, P. J. (2005). Trace elements in agroecosystems and impacts on the environment. *Journal of Trace Elements in Medicine and Biology*, *19*(2–3), 125–140. https://doi.org/10.1016/j.jtemb.2005.02.010
- Ibikunle, S. B., Arogunjo, A. M., & Ajayi, O. S. (2019). Characterization of radiation dose and soil-to-plant transfer factor of natural radionuclides in some cities from south-western Nigeria and its effect on man. *Scientific African*, *3*, e00062. https://doi.org/10.1016/j.sciaf.2019.e00062
- International Atomic Energy Agency. (2019). Guidelines on soil and vegetation sampling for

radiological monitoring. *Technical Reports Series No. 486, 486*.

- Kabata-Pendias, A. (2010). Trace elements in soils and plants: Fourth edition. In *Trace Elements in Soils and Plants, Fourth Edition*. https://doi.org/10.1201/b10158
- Kaur, S., Kaur, N., Siddique, K. H. M., & Nayyar, H. (2016). Beneficial elements for agricultural crops and their functional relevance in defence against stresses. In *Archives of Agronomy and Soil Science* (Vol. 62, Issue 7, pp. 905–920). https://doi.org/10.1080/03650340.2015.1101070
- Kohn, H. I. (1989). Sources, Effects and Risks of Ionizing Radiation. *Radiation Research*, *120*(1), 187. https://doi.org/10.2307/3577647
- La, S. (2014). *Potentially Harmful Elements in Agricultural Soils*. https://doi.org/10.1007/978-94-017-8965-3
- Lacstusu, R. (1998). Appraising levels of soil contamination y pollution with heavy metals. European soil bureau. *Research Report N^o 4*, *3*(2), 393–399.
- Matter, N. (2019). *Nuclear Decay*. https://doi.org/10.1016/B978-0-08-102702-8.00002-9
- Mugren, K. S. Al. (2015). Assessment of Natural Radioactivity Levels and Radiation Dose Rate in Some Soil Samples from Historical Area , AL-RAKKAH , Saudi Arabia. *Natural Science*, *May*, 238–247.
- Nations, U., Committee, S., Radiation, A., Assembly, G., & Annexes, S. (2008). *SOURCES AND EFFECTS United Nations Scientific Committee on the Effects of Atomic Radiation: Vol. I*.
- Njinga, R. L., Moyo, M. N., & Abdulmaliq, S. Y. (2013). Analysis of Essential Elements for Plants Growth Using Instrumental Neutron Activation Analysis. *International Journal of Agronomy*, *2013*, 1–9. https://doi.org/10.1155/2013/156520
- Points, K., Terms, K., & Nutrients, E. (2021). *31 . 1C : Essential Nutrients for Plants*. *C*, 1–4.
- Shoushtarian, F., & Negahban-Azar, M. (2020). World wide regulations and guidelines for agriculturalwater reuse: A critical review. *Water (Switzerland)*, *12*(4). https://doi.org/10.3390/W12040971
- Sorghum, G. (2012). Irrigation Water Guidelines. *Office*, 2–5. https://www.noble.org/globalassets/docs/testing-services/irrigation-water-guidelines.pdf
- Stanojković-Sebić, A., Maksimović, J., Dinić, Z., Poštić, D., Iličić, R., Stanojković, A., & Pivić, R. (2017). Microelements and heavy metals content in frequently utilized medicinal plants collected from the power plant area. *Natural Product Communications*, *12*(2), 185–188. https://doi.org/10.1177/1934578x1701200211
- States, U., & Radiation, N. A. (2019). *High Resolution Gamma-Ray Spectrometry Analyses For Normal Operations and Radiological Incident Response*. *October*.
- UNSCEAR. (2000). Sources and Effects of Ionizing Radiation, United Nations Scientific Committee on the Effects of Atomic Radiation UNSCEAR 2000 Report to the General Assembly, with Scientific Annexes. In *UNSCEAR 2000 Report: Vol. I*.
- Uosif, M. A. M., Issa, S. A. M., & Abd El-Salam, L. M. (2019). *Measurement of natural radioactivity in granites and its quartz-bearing gold at El-Fawakhir area (Central Eastern Desert), Egypt*. https://doi.org/10.1016/j.jrras.2015.02.005
- WHO. (2008). *Guidelines for Drinking-water Quality SECOND ADDENDUM TO THIRD EDITION WHO Library Cataloguing-in-Publication Data*. 17–19. http://www.who.int/water_sanitation_health/dwq/secondaddendum20081119.pdf