EMJ MS
EUROPEAN MULTIDISCIPLINARY JOURNAL OF MODERN SCIENCE
ISSN 2750-6274 https://emjms.academicjournal.io Volume: 13 | Dec-2022

Evaluation of Pollution Concentrations with Radioactive Elements in Some Industrial Areas

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Abstract: Pollution is a well-pronounced side effect of modern life techniques in every field, including the industrial one, so for estimating the size of pollution in the industrial areas sixteen samples were collected from five industrial sites, where samples were collected from within the work areas in the industrial areas. After collecting the samples, they were prepared for examination, where a high-purity germanium detector (HPGe) was used to detect radioactive elements. 226) and lead (Pb-214) of the uranium (U-238) series, and dour of actinium (Ac-228) and lead (Pb-212) of the thorium (Th-246) series and potassium (K-40). It was found that there are differences in the specific effectiveness between each of the industrial regions, after which the radium equivalent effectiveness, the internal and external hazard coefficient, and the internal and external equivalent annual dose were calculated and compared with the global limits.

Keywords: pollution, radionuclides, industrial areas.

Introduction

The natural and industrial sources of radiation continuously affect humans, as radiation surrounds us from almost every aspect, whether natural or industrial [1]. Radiation activity is one of the main influencers on environmental safety, it has an impact that lasts for several years and affects the health and safety of living organisms in addition to its effect on air, water, and soil [2]. Pollution is one of the major and serious problems humans face. There is an urgent need to intensify efforts to address and reduce them. The most problematic and complicated matter is that humans have the largest part in increasing its danger, through the activities we all carry out that threaten living organisms. This leads to a change in the natural balance of the environment and the various living components and others. [3] The issue of pollution is broad and complex, it includes several aspects of the environment, and radioactive pollution is one of those aspects, which is the result of introducing a radioactive substance into the environment. If the substance emits high radiation (gamma rays), then it causes an increase in the natural radioactive background, causing environmental damage that is directly proportional to the increase of these radioactive pollutants. But if the pollution is in the atmosphere, it will be transmitted to humans through inhalation or by depositing polluted dust on human skin [4]. It is known that the majority of people are constantly exposed to different levels of radiation present in the environment. Many people are also exposed to radiation in normal and harmless amounts [5]. Soil is one of the main reservoirs of many pollutants, including radioactive pollutants, which pollute the environment and thus disrupt the food chain [6]. Given the importance of the subject of radiation and its impact on the environment in terms of increasing the proportion of radioactive contamination, whether it is

from natural or industrial sources, it was necessary to detect it. Many studies were done aiming to measure the concentrations of radioactive materials in water, air, soil, plants, and many materials as building materials, aiming to help provide a better life for living organisms and also to show the extent of the influence of radioactive elements on the life cycle of the organisms [7].

Aim of this research

The research aims to measure the extent of pollution with radioactive elements, whether natural or industrial, by measuring (U^{238}), (Th^{232}), (K^{40}) and (Cs^{137}) in medical waste, and also to detect Iodine (I-131) which we expect to find in these areas using the HPGe detector, and then reveal the effects of gamma radiation on humans.

The theoretical side

Calibration of the detector

Calibration of the HPGe detector was performed by (Stander Sources multi-gamma CNF) as shown in Figure 1.

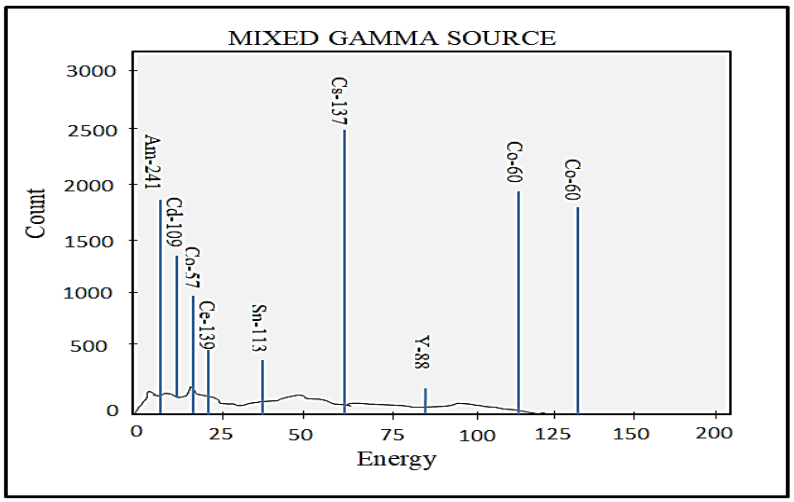


Figure 1 shows the calibration of the HPGe detector.

Calculating the separation capacity

To calculate the separation capacity of this device, we use equation 1

R= $\frac{\Delta E}{\Delta Ch}$ x FWHM. (Eq.1)

Where:

R: analytical capacity (separation capacity).

ΔE: the difference between two energies of the same element in the unit (Kev).

ΔCh: the difference between the peak and the calibration element is estimated by the channel unit

FWHM: width of the midline gamma line for peak height.

If we are to calculate the separation capacity for any of the radioactive elements and let it be (Co^{60}) according to equation 1

ΔE= $E_2 - E_2$ = 1332.5-1173.2= 159.3

ΔCh=Ch2-Ch1= 6195 – 5435= 760 ch

R= $\frac{\Delta E}{\Delta Ch}$ x FWHM= $\frac{159.3}{760}$ x 5.5= 2.2 (Kev)

The result that we obtained shows that the separation capacity of this device is very high, which means that the elements that appear in the measured samples can be adopted even if their energy reaches 2.2 (Kev).

Calculating the efficacy of the radioactive source

To calculate the effectiveness of the radioactive source (A), we use equation (2).

$A=A_0 e^{(-\lambda td)}$.(Eq.2)

Where:

A 0: the activity of the radioactive source when it is made.

λ: the radioactive source of nuclear decay constant.

td: the time between the date of manufacture and the date of measurement

The decay constant (λ) can be calculated from equation (3)

$\lambda = Ln(2)/t_{1/2}$. (Eq.3)

Calculation of the dose absorbed in the air from gamma rays (D_γ)

The average absorbed dose in the air from gamma rays can be calculated at a height of one meter from the earth's surface in (nGy / h) using the isotope efficacy which is thorium (Th^{232}), potassium (K^{40})and uranium (U^{238}) using equation 4 [8].

D_γ (nGy/h) = $0.462A_U + 0.604A_{Th} + 0.0417A_K$.(Eq.4)

Calculating the annual effective dose (AED)

The annual rate of the effective dose received by a person was calculated using the conversion factor of (0.7 Sv / Gy), which it was used to convert the rate absorbed in the air to the effective dose rate using the external (20%) and internal factor (80%), according to equations 3 and 4 [9].

$(AED)_{in}$ (mSv/y)= D_γ (nGy/h)×10^{-6}×8760 h/y×0.80×0.7Sv/Gy. (Eq.5)

$(AED)_{out}$ (mSv/y)= D_γ (nGy/h)×10^{-6}×8760 h/y×0.20×0.7Sv/Gy. (Eq.6)

Calculating the radioactivity concentration (I_γ)

The radioactivity index (I^γ) of the samples is calculated from equation 7. [10]

$$I_\gamma = \frac{A_U}{150} + \frac{A_{Th}}{100} + \frac{A_K}{1500} \quad \text{(Eq.7)}$$

Where: A is the activity concentration of the radioactive element.

Calculating the internal hazards of radioactivity (Hin)

Two indicators were identified by Mathew and Beretka in 1985 representing internal and external risks, with the aim of these indicators to reduce the radiation dose, knowingly the maximum value of radiation should be less than (1 mSv / y). The internal hazard index (H_{in}) is calculated using equation 8. [10]

$$H_{in} = \frac{A_U}{185} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \quad \text{(Eq.8)}$$

Calculating the external hazards of radioactivity (Hex)

To calculate the external risk index (Hex) of radionuclides, the equation below was used [11]

$$H_{ex} = \frac{A_U}{370} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \quad \text{(Eq.9)}$$

Calculating the equivalent dose for radium (Ra eq)

The equivalent value of this element is used to determine the risks of radium, thorium, and potassium. The element's concentration value can be estimated by equation (10).

Ra eq=CRa+1.43CTh+0.077CK (Eq.10)

Where:

(CRa): the concentration of radium or the resulting nuclide

(CTh): the concentration of thorium or the resulting nuclide

(CK): Potassium concentration.

The practical side

After defining the study areas, which included five industrial sites, samples were collected from the industrial areas from within the work areas, and the weight of each sample was 200 grams. Table 1 shows the areas from which samples were taken and the code for each area.

After collecting the samples, they were prepared, dried, and prepared for the examination, where an American-made high-purity germanium (HPGe) detector was used to examine the prepared samples. The examination was carried out at the Radiation Protection Center of the Iraqi Ministry of Health and Environment. This center was chosen for examination because the device in this center holds a globally recognized examination certificate, which is the ISO certificate. Figure 2 shows the high-purity germanium (HPGe) detector system.

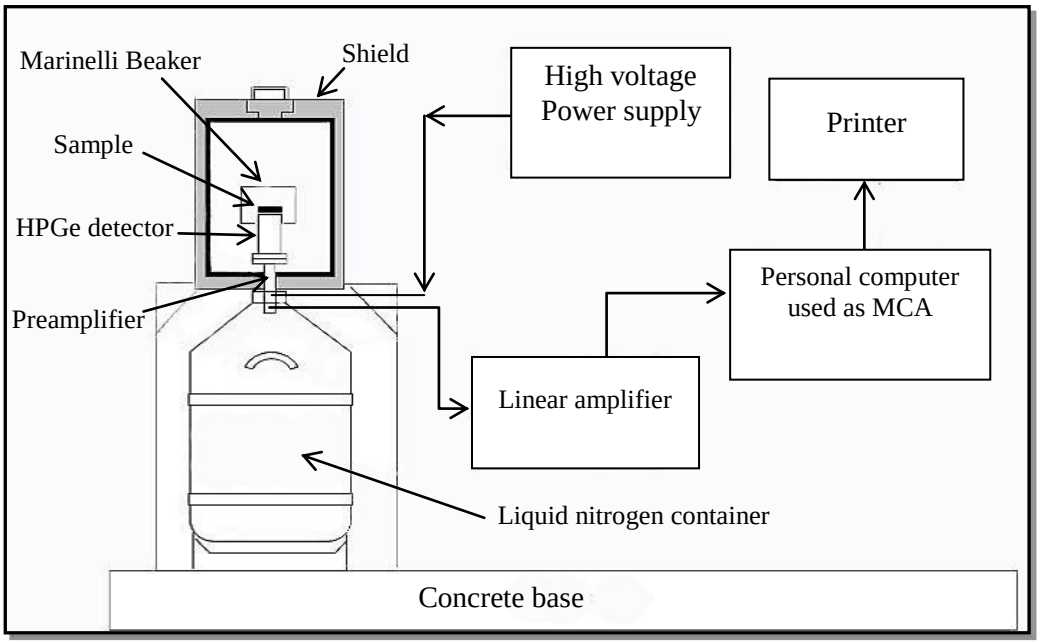


Figure 2 shows the system of high-purity germanium detector

Table 1 shows the study areas and their coordinates

Location Name	Symbol	Coordinates	
		Longitude	Latitude
AL-Tahadi ower station	F	42,4063	34,0442
Haditha Oil Refiery	G	42,3641	34,0678
Al-Qaim phosphate plant	PH	41,1975	34,2948
Al-Shaheed Wire Manufacturing Factory	C	43,816723	33,102373
Al-Ekhaa Metal Factory	Y	43,79898	33,159660

Table 2 shows the average radioactive elements measured for several countries.

Country	U-238 (Bq/kg)	Th-232 (Bq/kg)	K-40 (Bq/kg)	Reference
Egypt	7.68	8.07	27.20	[12]
Yemen	1.44	1.2	18.34	[13]
Iran	0.674	8.07	4.716	[14]
Saudi Arabia	0.17	3.3	339.2	[15]
Nigeria	7.75	19.09	-	[16]
India	56.74	87.42	143.04	[17]
Iraq	195.95	20.62	268.13	Current Study

Table 3 shows the concentration of radioactive elements in industrial areas

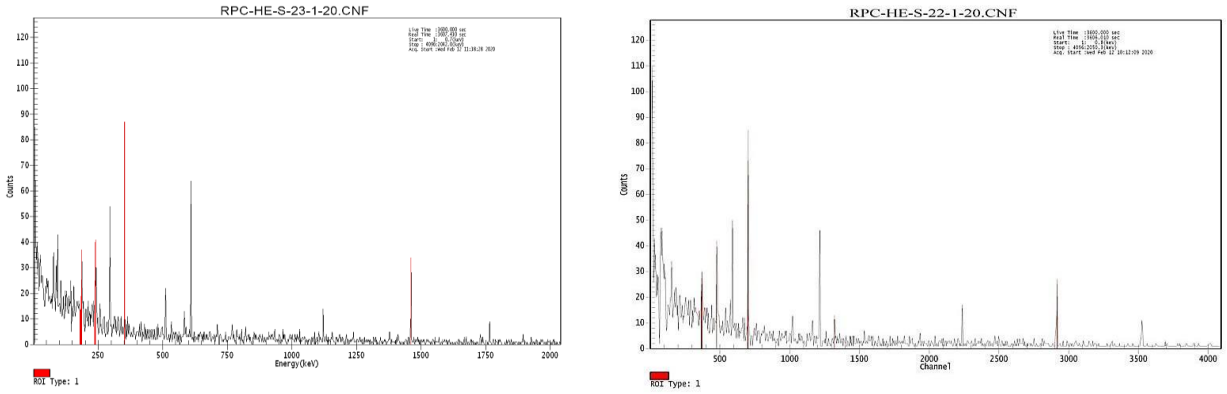
Region	**Sym**	**U-238 chain (Bq/kg)**		**TH-232 chain (Bq/kg)**		**K-40 (Bq/kg)**	**CS-137 (Bq/kg)**
		Ra-226	**Pb-214**	**Ac-228**	**Pb-212**		
AL-Tahadi ower station	**F1**	NF	79.4±14	NF	2.6±0.3	263.8±19	NF
	F2	101.3±27	84.5±14	NF	5.1±0.9	333±17	5.3±0.8
	F3	NF w	NF w	NF w	NF w	39.6±7	NF
Average		101.3±27	81.95±14	NF	3.85±0.6	212.13±14.3	5.3±0.8
Haditha Oil Refiery	**G1**	71.1±7	9±48	NF	4.5±0.7	174±2.1	NF
	G2	NF	12±3	NF	2.2±0.4	60.5±11	1.2±0.4
	G3	NF w	NF w	NF w	NF w	28.3±6	NF
	G4	NF w	NF w	NF w	NF w	262±15.7	NF
Average		**71.1±7**	**30±6**	**NF**	**3.35±0.5**	**131.2±8.7**	**1.2±0.4**
Al-Qaim phosphate plant	**Ph1**	1142±15.7	483±0.7	NF	13.5±4.1	481±19	38.4±5
	Ph2	265±16	182.3±17	42.1±9	21.6±4	884±29	48±7
	Ph3	NF	1727.9±150	NF	NF	170.6±11	NF
Average		**699±15.8**	**797.7±55.9**	**42.1±9**	**17.5±4.05**	**511.86±19.6**	**43.2±6**
Al-Shaheed Wire Manufacturing Factory	**C1**	70.5±13	22±4.9	19.6±5	14.±2.9	163.4±14	NF
	C2	NF	22.9±3.1	13±2	21.2±4.1	207±9.5	NF
	C3	NF	20.6±4	NF	11.3±0.7	160.7±7	NF
Average		**70.5±13**	**21.83±4**	**16.3±3.5**	**15.5±2.56**	**177.03±10.16**	**NF**
Al-Ekhaa Metal Factory	**Y1**	45±8	19.3±2.9	13.5±4.9	10.5±0.6	214.3±19	NF
	Y2	71.6±44	21.8±5	24.3±5.1	12±7.3	211±10	2±0.5
	Y3	NF	37.1±9	43±13	49±11	500±20	NF
Average		**58.3±26**	**26.06±5.63**	**26.93±7.6**	**23.83±6.3**	**308.43±16.3**	**2±0.5**
The overall average		**200.4±17.6**	**191.50±17.1**	**28.44±6.7**	**12.80±2.7**	**268.13±13.8**	**12.9±1.9**

Calculation of radiation hazard indicators

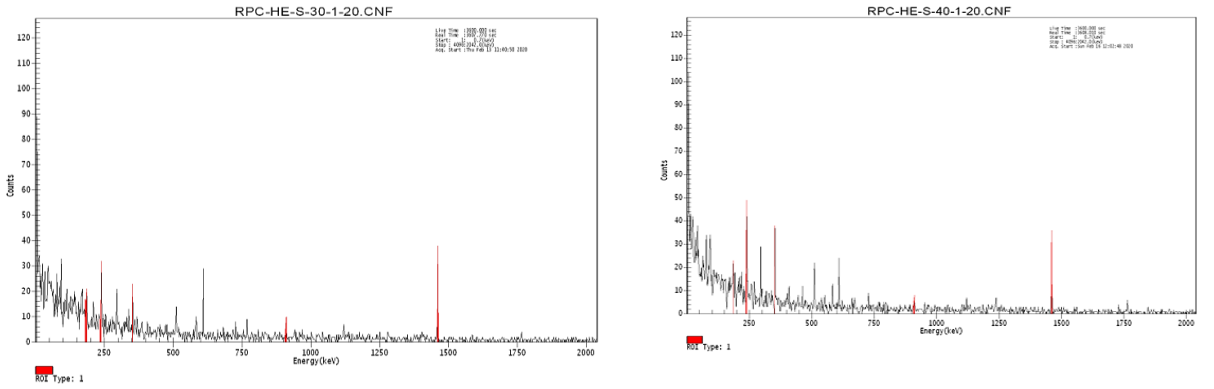
The hazard indicators for radioactive elements were calculated for each study area as shown in Table 4

NO	Sym.	Ra_{eq} (Bq/kg)	D (nGy/h)	Hazard index		A.E.D (mSv/y)		I^{γ}
				H_{ex}	H_{in}	E_{in}	E_{out}	
1	F	113.43	53.47	0.306	0.554	0.262	0.065	0.729
2	G	65.39	30.83	0.176	0.313	0.151	0.037	0.457
3	PH.	830.32	384.87	2.243	4.266	1.888	0.472	5.629
4	C	82.51	38.56	0.222	0.347	0.189	0.047	0.584
5	Y	105.68	49.62	0.285	0.399	0.243	0.060	0.764
Global limit[18]		**370**	**55**	**1**	**1**	**1**	**1**	**1**

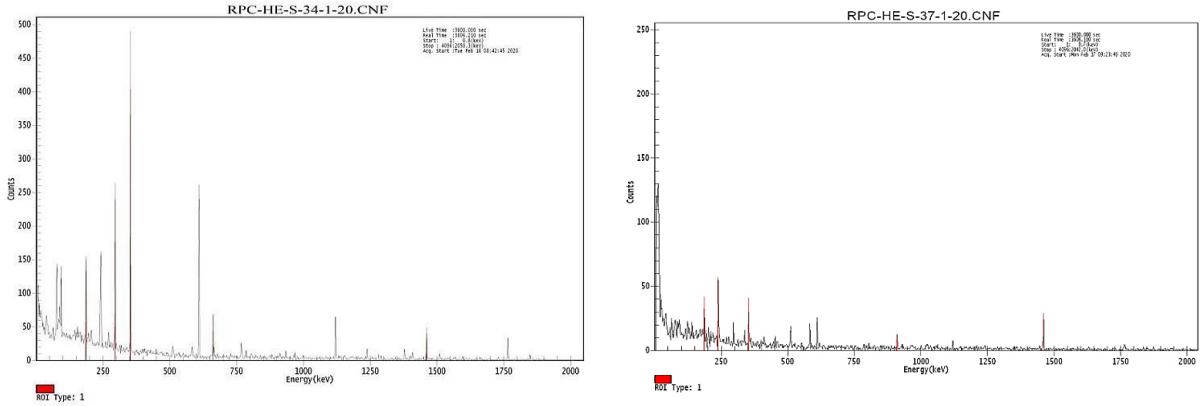
The following figures show the gamma-ray spectrum of some samples of industrial areas



Gamma-ray spectrum of the sample (g1). Gamma-ray spectrum of the sample (F2)

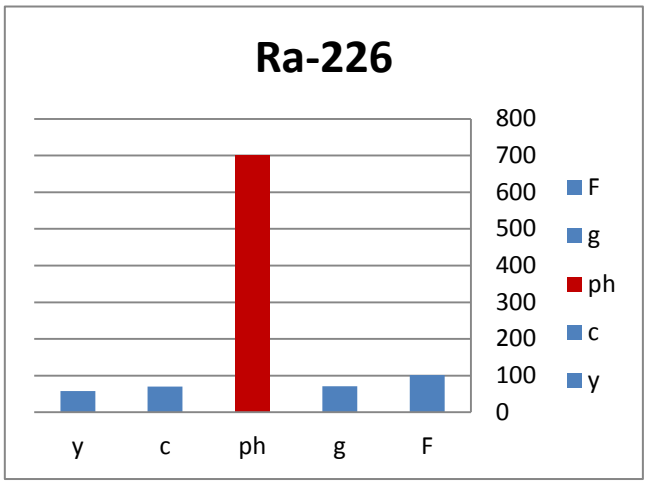


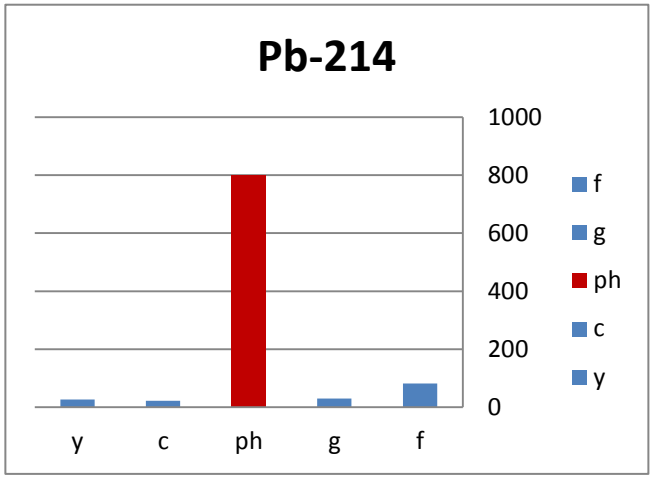
Gamma-ray spectrum of the sample (C3).Gamma-ray spectrum of the sample (Y1).

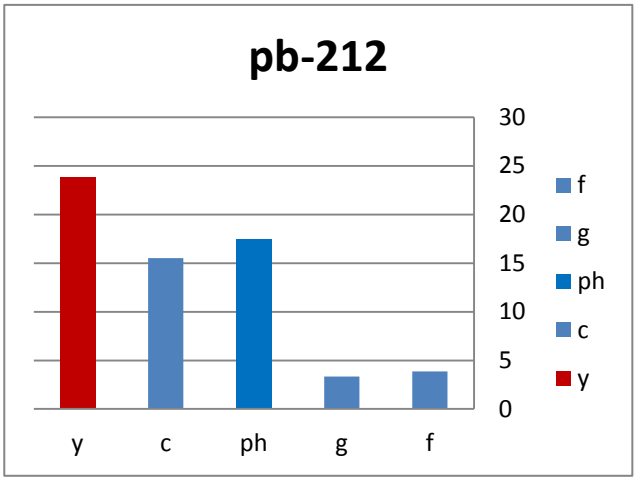


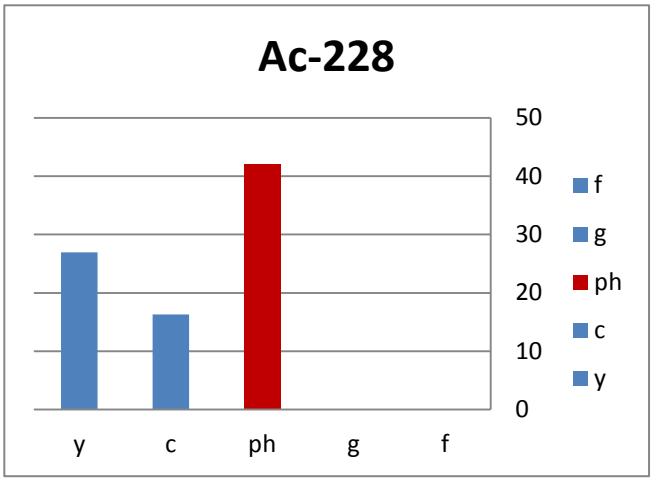
Gamma-ray spectrum of the sample (C1). Gamma-ray spectrum of the sample (Ph1).

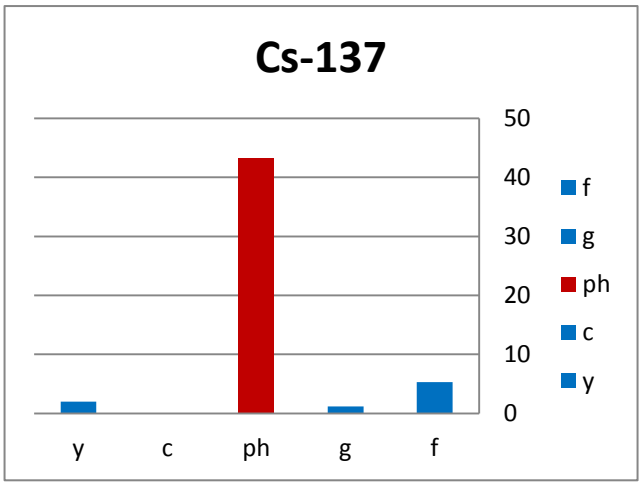
The following figures show the concentrations of radioactive elements in industrial areas

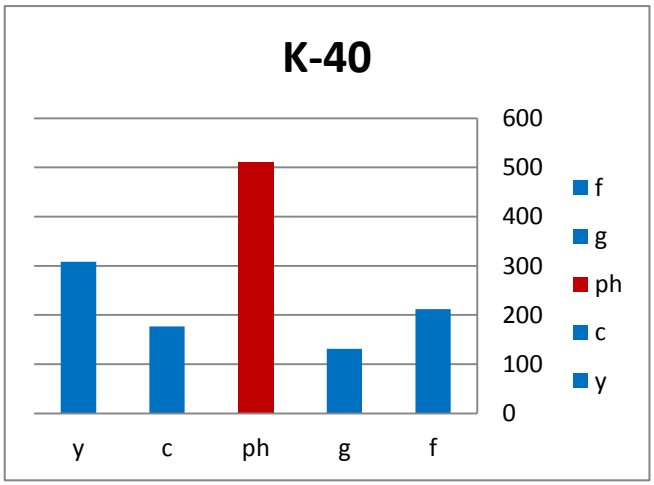












Results and discussion

After examining the samples, several radioactive elements appeared, namely radium (Ra-226), lead (Pb-214) of the uranium chain (U-138), akenium (Ac-228), and lead (Pb-212) belonging to the series of thorium (Th-232) and potassium (K-40) and the appearance of cesium (Cs-137) in some industrial areas. Table 2 shows the rate of measured radioactive elements for some international countries, and Table 3 shows the rate of radioactive elements obtained from examining samples in industrial areas.

After examining the samples and obtaining the results and taking the examination rate for each of the study areas, it was found that the radioactive elements belonging to the uranium series (U-238), which include radium (Ra-226) and lead (Pb-214) appeared in greater proportions in some areas where the rate of the element of Radium in the residues of Al-Qaim Phosphate Plant was (699±15.8), followed by Al-Tahadi power plant in Haditha (F) with a rate of (101.3±27), followed by Haditha refinery with a rate of ((71.1±7), followed by Al-Shahid Company in Ameriyat Al-Fallujah with a rate of (70.5±13) as for the element Lead (Pb-214) it appeared in high percentages in Al-Qaim phosphate plant, with a rate of (797.7 ± 55.9), followed by Al-Tahadi power plant in Haditha with a rate of (81.95 ± 14), followed by Haditha refinery with a rate of (30 ± 6).

As for the thorium series, which includes the two elements Actinium (Ac-228) and lead (Pb-212), where some areas showed an increase in the proportions of the two elements, where Actinium (Ac-228) appeared in the existing phosphate plant with a percentage of (42.1±9), followed by Al-ikha'a company in Amiriyat al-Fallujah With a percentage of (26.93 ± 7.6), followed by Al Shaheed Company in Ameriyat al-Fallujah with a rate of (16.3 ± 3.5), while this component did not appear in the rest of the regions. As for lead (Pb-212), it appeared in high percentages in Al-ikha'a Company in Ameriyat Al-Fallujah at a rate of (23.83 ± 6.3), while the rest of the areas ranged between (3.35 ± 0.5) and (17.5 ± 4.05). As for potassium (K-40), it appeared in high proportions, especially in Al-Qaim phosphate plant, and it was at a rate of (511.8 ± 19.6), followed by Al-Ekhaa Company in Ameriyat Al-Fallujah with a rate of (308.4 ± 16), and followed by the Al-Tahadi power plant in Haditha with a rate of (212.1 ± 14.3). It is followed by Al-Shahid Company in Amiriyat Fallujah with a rate of (177.03 ± 10.16), followed by the Haditha refinery with a rate of (131.2 ± 8.7) As for cesium (Cs-137), it appeared in Al-Qaim phosphate plant, Haditha refinery, Al-Tahadi power plant in Haditha and Al-ikha'a Company in Fallujah. It was at high rates in Al-Qaim phosphate plant with a rate of (43.2±6), followed by Al-Tahadi power plant in Haditha with a rate of (5.3 ± 0.8), followed by Haditha refinery with a rate of (1.2 ± 0.4).

Through the study and examination of the samples taken from the study areas, it was found that they contain a large percentage of uranium chains (U-238), thorium chains (Th-232), potassium (K-40), and cesium (Cs-137) due to the diversity of industries, works, and materials used in those regions, which led to the emergence of high results for some elements.

References

1. Al-Janabi, Musa, "The Atomic Universe", Iraqi Atomic Energy Publications (1987).
2. Abdel-Mahmoud, Abdel-Kari. M, "Environmental and health impact of radioactive materials", decisions of the scientific conference on the impact of the use of depleted uranium on humans and the environment in Iraq, Part One, pg. 15, Baghdad - Iraq. (2002).
3. Mouloud Bahram Khader and others, Environmental Science, Ministry of Higher Education and Scientific Research, Dar al-Kutub for Printing and Publishing, University of Mosul, pp. 39 and 43.
4. Ibrahim Haddad, "Radioactive Pollution, Its Sources and Impact on the Environment," Arab Organization for Education[5], Culture and Science, Science Administration, Tunis, 1992.
5. International co,,mission on radiological protection, ICRP Publication 60 Annapls of the ICRP 21, p.22,(ICRP 1990).
6. Abdullah, Muhammad Siddiq Muhammad, Legal Protection of the Environment from Pollution, College of Law, University of Mosul, Al-Rafidain Journal of Law, (2007).

7. Al-Rahal, Esraa Kamel, "Calculation of uranium concentrations and transfer coefficients in phosphate fertilizers from soil to plants using the nuclear trace detector (CR-39)" Master's thesis, University of Baghdad, College of Science for Girls, (2008).
8. NEA-OECD, Exposure to radiation from the natural radioactivity in building materials. Report by an NEA group of experts, (1979)78-79
9. United Nations Scientific Committee on the Effects of Atomic Radiation, Sources and Effects of Atomic Radiation, Report to General Assembly, UNSCEAR, United Nations, (1993).
10. IAEA, The Use of Gamma-Ray Data To Define the Natural Radiation Environment, Int. At. Energy Agency (1990) 49.
11. A. Jose, J. Jorge, M. Cleomacio, V. Sueldo, D.S. Romilton, Analysis of the K-40 levels in soil using gamma spectrometry, Brazilian archives of biology and technology 48 (2005) 221-228.
12. H. El-Gamal, A. I. A. El-Mageed, Natural Radioactivity in Water Samples from Assiut City, Int. J. Pure Appl. Sci. Technol, 22 (2014) 44–52.
13. S. Harb, A.H. El-Kamel, A.M. Zahran, A. Abbady, F.A. Ahmed, Assessment of natural radioactivity in soil and water samples from Aden governorate south of Yemen region, International Journal of recent research in Physics and Chemical Sciences, 1 (2014)1-7.
14. E. Ehsanpour, M.R. Abdi, M. Mostaj, H. Bagheri, ^{226}Ra, ^{232}Th and ^{40}K contents in water samples in part of central deserts in Iran and their potential radiological risk to human population, Journal of Environmental Health Science & Engineering 12 (2014) 1–7.
15. A.A. Fakeha, S.Q. Hamidalddin, Z.M. Alamoudy, A.M. Al-Amri, Concentrations of natural radioactivity and their contribution to the absorbed dose from water samples from the Western Province, Saudi Arabia, JKAU Sci. 23 (2011) 17-30.
16. O.S. Ajayi and G. Adesida, Radioactivity in some sachet drinking water samples produced in Nigeria, Iran. J. Radiat. Res. 7 (2009) 151–158.
17. S. Surinder, R. Asha, K.M. Rakesh, ^{226}Ra, ^{232}Th and ^{40}K analysis in soil samples from some areas of Punjab and Himachal Pradesh, India using gamma-ray spectrum, radiation measurements, 39 (2005) 431-439.
18. UNSCEAR, United nations scientific committee on the effect of atomic radiation, Report to the general assembly. Annex B: Exposures from Natural Radiation Sources, New York, (2000).