Determination of the Specific Activity for the natural radioactive isotopes (^{40}K ,^{212}Pb, ^{214}Pb ,^{214}Bi,^{228}Ac) in soils and sediments for selected areas of the marshes southern Iraq, Basra province and the northern Arabian Gulf

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Abstract

The radioactive background in the environment of Southern Iraq and areas of Basra Province was determined by Radioactive Activity measurement of (^{40}K, ^{212}Pb,^{214}Pb,^{214}Bi, ^{228}Ac) in both soil and sediment mud by using a Gamma Ray Spectrometry analysis system that have high-purity germanium detector, with energy resolution 1.8 keV analytical ability in energy of 1332Kev and efficiency up to 40%. Gamma Vission program equipped by US Aortek company has been used to extract the data from the resulted Spectra and complete the process of spectral analysis.
The measurements included 15 locations of Southern Iraq marshes' environment and areas in Basra Province. The Specific Activity measurements results were around [320.1 - 1310.9 Bq/kg for ^{40}K, 0 – 12.1 Bq/kg^{212}Pb, 0 – 6.3 Bq/kg for ^{214}Pb, 3.2 -10.2 Bq/Kg for^{214}Bi, and 0 – 4.4 Bq/Kg for ^{228}Ac].
When the results of the studies were compared against results of other areas in Iraq and the world, it was noticed that the gained values are matching with some other studies but the difference might be due to the geographical and geological factor of those areas.

Key word :- Specific Activity, Sediments, Gamma Ray Spectrometry, Isotopes (^{40}K, ^{212}Pb, ^{214}Pb, ^{214}Bi, ^{228}Ac).

1. Introduction

Day by day, increased dependence on ionizing radiation in various aspects of life such as industrial, scientific, medical, military life aspects, and the scopes of using these rays became one of the means in the industrial progress and age's technology in spite of the adverse risks to humans.
Besides the above mentioned, there are a lot of natural radioactive elements that pollute the environment other than the nuclear uses, mostly these elements are caused by some industrial waste like the cement, phosphate and petrochemical
industries, oil and gas extraction and production.

It should be noted that during the Second Gulf War in 1991 and the occupation of Iraq in 2003. The environment in Iraq, especially the southern region has been exposed to a new generation of Weapons that contain nuclear material.
Naturally Occurring Radioactive Materials (NORM) are belong to one of the natural radioactive decay series which are Uranium series ^{238}U , Actinium $^{235}U$and Thorium ^{232}Th. Emit from those elements different types of ionizing radiation in the environment and these radiation accompanied with the dissolution of Potassium isotope ^{40}K (UNSCEAR 2000,2006), (M. K. khodiar 2014)

Some of natural radioactive elements have a half-life of hundreds of million years and this period is almost the age of earth (World Health Orgnization 2004). The existence of natural Uranium or one of its products degradation series in the environment in large quantities either in soil or water is a major source of radioactive pollution. The radioactive background in that area is relatively high which cause a great damage to human health and the environment as indicated by many researchers (Al-Jundi *etal* 2003), (Sigh S., *etal* 2005) . As a result of dusty wind coming from various quarters to cities from a time to another Lead to the transfer of dust contaminated by radiation to the cities and villages in its way and thus cause an increase of radioactive contamination (Technical Reports Series 1989). when the air polluted will lead to the spread of pollution in wide areas, as winds will move the radioactive cloud- as in the Chernobyl incident-(GEMS/Food Total Diet Studies Report 1999) and in turn will cause in polluting land and water by dropping the radioactive dust over them GEMS/Food Total Diet Studies Report 1999), (A. S. Mohammed*etal* 2013)

The human body is exposed to radioactive isotopes directly by the process of external exposure to the radioactive material that are deposited on the surface of Earth, or as a result to inhaling the lingering radioactive material in the air. While the indirect method for receiving radiation it's going to be through food and water, or the intervention of radioactive isotopes in the soil to plants then to humans and animals through the food chain, the radioactive isotopes move from soil to plant's tissues as well through the roots or the adsorption by metabolic processes that take place in leaves (Rasheed M. Yousuf*etal* 2008)

Both Bismuth Isotope ^{214}Bi and Lead Isotope ^{214}Pb are from the most dangerous solid products of Radon Gas ^{222}Rn because of its very small half-life and they are within the products of Uranium ^{228}U degradation series, as the ratio of the ^{238}U is (99.79%) of depleted Uranium which its amount is 19.04 gm/cm^3(Dietz, L. A., 1993). Radon Gas ^{222}Rn forms a major threat to human and animal lives, as inhaling it is the primary cause of lung cancer (ICRP, 2006), (Al-Sultaiti, H., Nasir, T., *etal* 2012) because of its lefts that will stick to the liner of the lung.
Lead Isotope ^{212}Pband Actinium Isotope ^{228}Ac are resulted of the ^{232}Th degradation series and their half-life is 6.1, 11 hours in sequence, and they are products of Radon ^{220}Rn which is more dangerous than the Radon Isotope ^{222}Rn due to its little half-life which is 56 seconds.

Potassium ^{40}K is one of the natural radioactive isotopes that contributes with the biggest radiation dose entering human bodies, as well as the Potassium is the key element in the muscle cells then the pollution relatively be bigger (Mollah, A.S., *etal* 1996). If a human' body weights 70 kg, the potassium in that body is about 160 g which is equivalent to a degeneration of 4900 nucleus of Potassium ^{40}K per second (Supian Bin Samat,*etal* 1997)

The study of radioactivity in South Region is essential especially when it comes to human health and environment, as well as the assessment of radiation risks resulting from nuclear accidents or the use of radioactive materials in the regional struggles (Laboratory Procedures Manual, report, 1994).

2. Theory

The radioactive decay rate (Radioactivity) A(t) in sample given in the following equation :

$$A(t) = A_0 e^{-\lambda t} \quad (1)$$

Were A_0It represents the radioactivity at the start time t = 0,A_t radioactivity after a time of t, λrepresents a constant decay of radioactive material,λ can be calculated from the following equation (W. e. Mayerhof ,1967) :

$$\lambda = \frac{0.693}{T_{1/2}} \quad (2)$$

Were $T_{1/2}$is represents the half-life of the sample.

The measurements unit of radioactivity is Becquerel(Bq),which evens one analysis per second (*dps)*.Alsoradioactivity measured by using Curie unit Ci, Which is defined as the radioactivity of one gram of radium ^{226}Ra, which is equivalent to $3.7x10^{10}$ Becquerel.The specific activity (specificconcentration)A_s(Bq/kg)is calculated according to the standards of the International Atomic Energy Agency for International as follows (W. e. Mayerhof ,1967):

$$A_s\left(\frac{Bq}{kg}\right) = \frac{\sum N}{\varepsilon I_\gamma mt} \qquad (3)$$

Were $\sum$N is the Net Count (cps), ε: System Detection Efficiency (always less than 1), I_γ: Absolute Transition Probability for gamma decay, m: Mass of the sample (kg), t: Time of Counting (sec).

3- Area of Study

The area of study is located in South of Iraq within the sedimentary plain area, and positioned between the longitudes (48^0 30') and (46^0 59') to the east, (31^0 45 ') and (29^0 39') latitudes to the north.The area includes the marshes of Southern Iraq (Al-hoiza, Chebaish, and Al-Hammar Marshes) besides selected areas of Basra province, Shatt Al-Arab and North-West of Arabian Gulf, as shown in the

map in Figure No. (1).

4. Samples Collection

The samples were collected from specific sites in the area of study in accordance of the international Atomic Energy Agency (IAEA). A group of at least six samples were taken from thesoil for a minimum of 10 m^2 especially from the with the recommendations of The Internationalfour corners of each site in a depth between(0-15) m. Muddy sediments of water bodies were collected as well from Shatt Al-Arab and Arabian Gulf using a collector of mud samples (Grap Sampler).

5. Preparation of samples:

The sample were prepared after transfer to Maritime Radioactive Contamination Lab where soil samples and sediments mud dried after purification from impurities and outstanding solids in a drying oven on $105C^0$ for one week, then milled and sifted by 2mm sieve. Each sample was packed with a weight of 500 gm in plastic bags labeled by a code indicating the sample type and location.

6. Measurement of Samples:

After preparation of laboratory samples, they were sent to Ministry of Science and Technology/ Radioactive Waste Treatment Directorate/ Laboratory physical properties, in order to measure their concentration level by using Gamma Rays Spectrometry system.In this system a germanium detector with high purity was used, with energy resolution 1.8 KeV in energy of 1332 Kev, besides an efficiency up to 40%, The system used a program of Gamma Vission-32 equipped by US Aortek company to extract the data from the resulted Spectra and complete the process of spectral requirements as mentioned above.

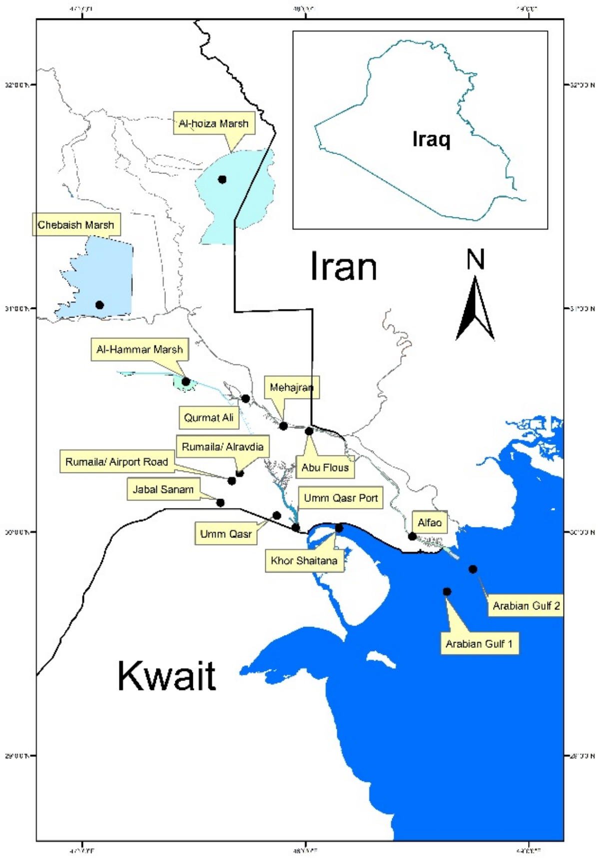

Figure 1: Map of studyarea

7. Results and discussion:

7.1Specific activity of Potassium ^{40}K in soil and sediments for the areas of the study:

Potassium is one of the most basic mineral elements in Earth's crust, and it has three natural isotopes (^{39}K, ^{40}K, ^{41}K). Potassium ^{40}K has a half-life of ($1.28x10^9$y) which emits gamma ray and beta particles. Due to its abundance in nature that reaches to 0.01178% of the total Potassium (Hil Rutherford, 2002), the ^{40}K is the most effective in Earth's crust and it does not belong to the two radioactive series ^{238}U and ^{232}Th. Therefore studying it considered as a fundamental of natural radiation background.

After collecting the samples and laboratory preparation, Gama Spectrum for samples had been studded. Then determine the Potassium ^{40}Kpeak site. The maximum value in the peak at 1460 Kev is belong to Potassium ^{40}K, The specific activity was calculated after knowing the quality intensity of Potassium ^{40}K and efficiency of the counter.

Table (1) shows the specific activity of Potassium ^{40}K in soil and mud sediment and clearly notice a discrepancy between the values of the ^{40}K specific activity according to the study area as in Fig. (2).

Table (1) specific activity of Potassium ^{40}K in soil and sediments for the areas of the study

No.	sample	Type of sample	Area of collect	Position	specific activity A_c (Bq/kg)
1	S1	sediments	Qurmat Ali	47^{o} 43' 56.366" E 30^{o} 35' 48.531" N	570.2
2	S2	sediments	Al-Hammar Marsh	47^{o} 27' 2.254" E 30^{o} 41' 20.423" N	750.0
3	S3	sediments	Umm Qasr Port	47^{o} 57' 9.21" E 30^{o} 1' 41.869" N	770.8
4	S4	sediments	Khor Shaitana	48^{o} 8' 49.877" E 30^{o} 2' 0.307" N	800.0
5	S5	sediments	Arabian Gulf 1	48^{o} 37' 43.086" E 29^{o} 44' 47.757" N	740.8
6	S6	sediments	Arabian Gulf 2	48^{o} 44' 47.169" E 29^{o} 50' 38.087" N	700.1
7	S7	sediments	Alfaw	48^{o} 28' 29.934" E 29^{o} 59' 32.800" N	850.5
8	S8	sediments	Abu Flous	48^{o} 0' 50.478" E 30^{o} 27' 12.256" N	1020.5
9	S9	sediments	Mehajran	48^{o} 37' 43.086" E 29^{o} 44' 47.757" N	1020.0
10	B1	soil	Qurmat Ali	47^{o} 43' 56.366" E 30^{o} 35' 48.531" N	500.1
11	B2	soil	Umm Qasr	47^{o} 51' 55.765" E 30^{o} 5' 41.568" N	630.8
12	B3	soil	Al-hoiza Marsh	47^{o} 37' 29.16" E 31^{o} 34' 11.827" N	320.1
13	B4	soil	Rumaila/ Airport Road	47^{o} 40' 13.5" E 30^{o} 13' 45.2" N	690.4
14	B5	soil	Rumaila/ Alravdia	47^{o} 42' 18.11" E 30^{o} 15' 49.2" N	690.2
15	B6	soil	Jabal Sanam	47^{o} 36' 52.283" E 30^{o} 8' 27.514" N	1310.9

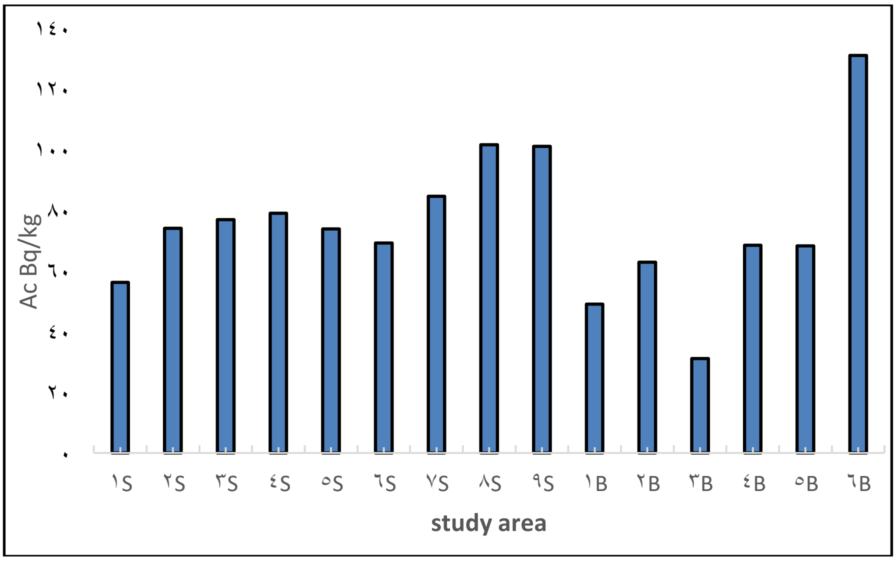

Figure 2: A comparison specific activity of ^{40}K in soil and sediment mud within areas of the study.

7.2 Specific activity of ^{212}Pb, ^{214}Pb, ^{214}Bi & ^{228}Ac in soils and sediments for the areas of the study:

The samples were collected from the study areas as shown in table(1) , prepared and sent to the Radioactive Waste Treatment Directorate for measurement. The Specific activity values in table(2) are related to the samples of the above mentioned elements compared to fingers(3,4,5 & 6).

Table (2) specific activity of ^{212}Pb , ^{214}Pb, ^{214}Bi &^{228}Ac in soil and sediments for the areas of the study

No.	Simple of sample	Specific activity of ^{212}Pb	Specific activity of ^{214}Pb	Specific activity of ^{214}Bi	Specific activity of ^{228}Ac
1	S1	12.10	0.59	4.30	3.20
2	S2	N.D*	3.20	3.20	N.D*
3	S3	10.00	3.40	6.19	2.90
4	S4	11.75	2.80	6.80	1.31
5	S5	11.00	4.80	10.20	2.80
6	S6	10.60	4.00	9.60	4.40
7	S7	11.10	3.20	9.80	2.03
8	S8	8.09	N.D*	8.60	N.D*
9	S9	6.50	3.20	7.00	N.D*
10	B1	N.D*	3.20	3.20	N.D*
11	B2	7.00	2.90	5.90	1.80
12	B3	11.50	2.96	6.70	2.80
13	B4	5.30	5.20	6.40	1.60
14	B5	8.89	6.30	9.20	3.60
15	B6	9.20	3.40	6.16	4.00

*(N.D) Not Detect

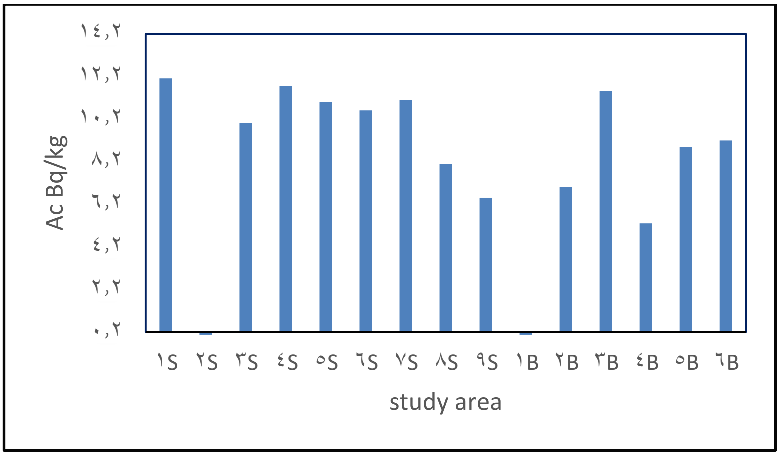

Figure 3:A comparison specific activity of ^{212}Pb in soil and sediment mud within areas of the study.

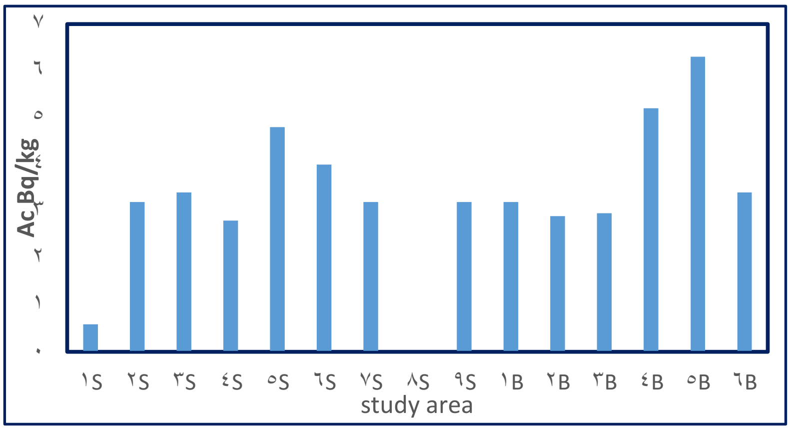

Figure 4:A comparison specific activity of ^{214}Pb in soil and sediment mud within areas of the study.

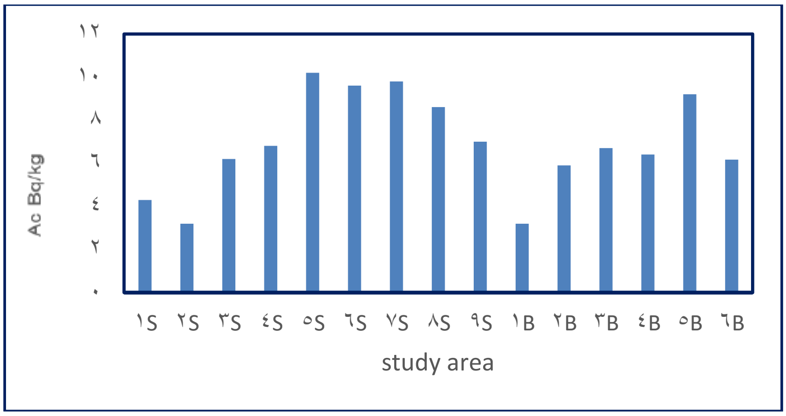

Figure 5: A comparison specific activity of ^{214}Bi in soil and sediment mud within areas of the study.

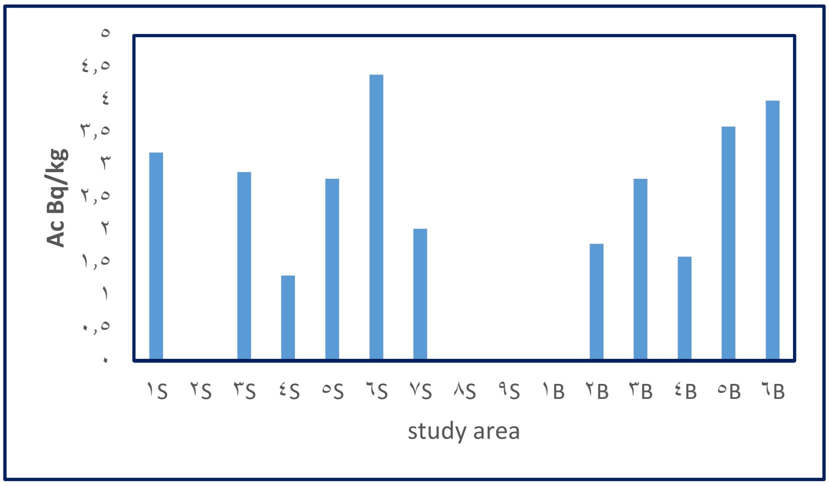

Figure 6: A comparison specific activity of Actinium ^{228}Ac in soil and sediment mud within areas of the study.

Conclusion

It's seen from the above tables and figures the revealed Specific activity after spectral analysis which were calculated for these nuclides that are natural radionuclides within the natural decay outputs of Thorium ^{232}Th and Uranium ^{238}U series besides the Potassium isotope ^{40}K as all of them were a part of the normal range. Potassium isotope ^{40}K quality effectiveness in this study of soils and sediments are fairly consistent with other studies around the world with some differences that might be due to the geology and geography of these areas (Rasheed M. Yousuf etal 2008),(Hamid, B.N., Chowdhry, 2000), (Nasim, A.O.,2003), (Piotr Godyn, *etal* 2014) as shown in figures (7) and(8).

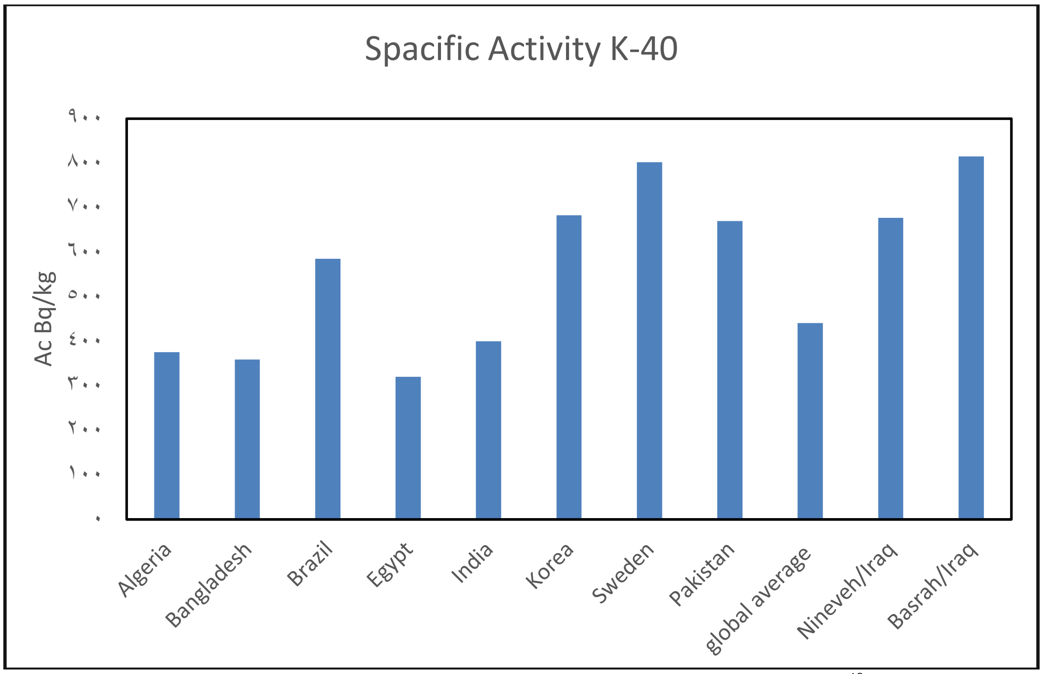

Figure 7:A comparison the current study with other studies of specific activity for ^{40}K (Rasheed M. Yousuf etal 2008).

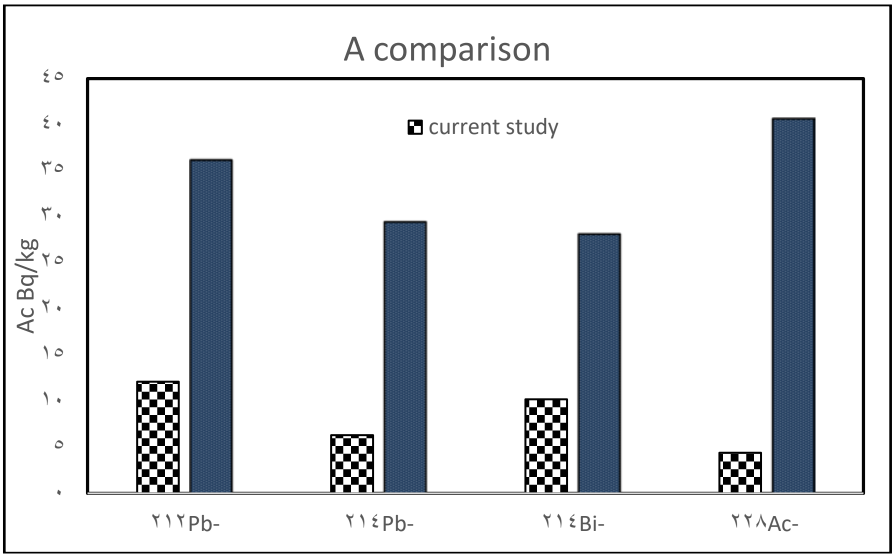

Figure 8:A comparison the current study with other studies of specific activity for ^{212}Pb, ^{214}Pb, ^{214}Bi & ^{228}Ac(Piotr Godyn, etal 2014)

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Piotr Godyn. Agnieszka Dołhanczuk-Srodka. Zbigniew Ziembik. Ewa Moliszewska,

تحديد الفعالية النوعية للنظائر المشعة الطبيعية ($^{228}Ac, ^{214}Bi, ^{214}Pb, ^{212}Pb, ^{40}K$) في ترب وترسبات مناطق مختارة من اهوار جنوب العراق,محافظة البصرة وشمال الخليج العربي.

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المستخلص

حددت الخلفية الاشعاعية في بيئة اهوار جنوب العراق ومناطق من محافظة البصرة وشمال الخليج العربي من خلال قياس النشاط الاشعاعي لكل من ($^{228}Ac, ^{214}Bi, ^{214}Pb, ^{212}Pb, ^{40}K$) في كل من التربة والترسبات الطينية، باستخدام منظومة تحاليل أطياف اشعة كاماGamma Ray Spectrometry فيها كاشف جرمانيوم عالي النقاوة ، الذي يتصف بقدرة تحليلية مقدارها 1.8Kev في طاقة 1332Kev وبكفاءة تصل الى 40%، ويستخدم في المنظومة البرنامج Gamma Vission المجهز من شركة اورتك الامريكية لاستخلاص البيانات من الاطياف الناتجة واتمام عملية التحليل الطيفي.

شملت القياسات 15 موقعا لبيئة اهوار جنوب العراق ومناطق من محافظة البصرة وشمالالخليجالعربي. وقد تراوحت نتائج قياس الفعالية النوعية لـ K^{40}بين (320.1 - 1310.9)Bq/kg ، اما بالنسبة لـ Pb^{212}فقد تراوحت النتائج بين (0 – 12.1)Bq/kg، وللـ Pb^{214} فقد تراوحت النتائجبين (0 – 6.3)Bq/kg ، في حين كانت النتائج لـ Bi^{214} تتراوح بين (3.2 -10.2)Bq/Kg ، واخيراً لـ Ac^{228} فـــــقد تراوحـــــت النتائج بين (0 -4.4)Bq/kg.لدى مقارنة النتائج مع دراسات أجريت في مناطق أخرى من العراق والعالم لوحظ ان القيم التي تم الحصول عليها تتفق مع بعض الدراسات الاخرى وان وجود بعض الاختلافات قد يعزى الى جغرافية وجيولوجية تلك المناطق.

كلمات مفتاحية:- الفعالية النوعية ، الرواسب،منظومة أطياف كاما، نظير البوتاسيوم ^{40}K،نظير الرصاص^{212}Pb، نظير الرصاص^{214}Pb، نظير البزموث^{214}Bi ، نظير الاكتنيوم ^{228}Ac.