*IOSR Journal of Applied Physics (IOSR-JAP)*
*e-ISSN: 2278-4861.Volume 10, Issue 3 Ver. III (May. – June. 2018), 43-49*
*www.iosrjournals.org*

# Measurement of Radioactivity inMarsh Sediments of South Iraq

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***Abstract:*** *Sediment samples were collected from chosen regions of main marshes in southern Iraq and tested for radioactivity from both natural and artificial sources using gamma spectroscopy doped with a high purity germanium coaxial detector (HpGe). Qualitative measurements for 9 samples were made, and the results showed that most sediments samples exhibited natural radioactive level and sometimes less than the international regular standards. The radioactivity of Ra-226 belongs to the U-238 chain was measured with average specific activity concentration (S.A) 23.95 Bq/kg, the average specific activity concentration (S.A) of Ac-228 was found rather than Th-232 but with low specific activity concentration (S.A) about 11.97Bq/kg and K-40 with specific activity concentration (S.A) 250.24Bq/kg. Cs-137 was detected in 6 of these samples with specific activity concentrations varied from 0.47 to 3.3 Bq/kg. Radium equivalent activity (REA), the internal and external hazards indexes, and the rate of absorbed dose equivalent to human were estimated. All the measured samples exhibited natural radioactive levels.*

***Keywords:*** *Sediment, artificial sources, Radium equivalent activity (REA), absorbed dose, hazards indexes, Specific Activity (S.A).*

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Date of Submission: 07-06-2018 Date of acceptance: 26-06-2018

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## I. Introduction

The world of marshes in terms of its natural and social components is a living extension of ancient history due to the persistence of primitive life forms such as reeds, boats, transport, and fishing, despite the tremendous development that has influenced the life aspects of the world surrounding the marshes[1].The main southern marshes of Iraq (Hor Al-Huwayzah, HorAl-Hamar, and the central marshes) occupy large areas in the shape of a triangle headed towards the city of Basra. Its base is heading north, represented by the line connecting the cities of DhiQar, andMaysan Water is generally supplied by the Tigris and Euphrates rivers, as 80 % of the water of these rivers is lost in marshes with a water depth of 2-5m [2, 3]. That the marshes that huge water swamp, which represents a geographical unit, natural is one of the richest areas of the world, in terms of the diversity of aquatic life and land, a reservoir of great water for fresh water that can be used for drinking water and inhabited by man and lived on him and his goods and this feature was not available in Fresh lakes located behind dams for lack of difficulty of these activities [4].

The southern region of Iraq, including the marshlands of Maysan province and the Shatt al-Arab area of Basra governorate, is one of the most exposed to the danger of radioactive contamination resulting from the presence of fragments of depleted uranium shells, shields and damaged mechanisms and dust of $UO_2$ as a result of wars or water flow from neighbouring countries Radioactive, chemical and organic wastes. The aquatic environment loses the aesthetic character of rivers and lakes and damage to fish wealth [5].A number of studies [6, 7] concerned the study of the environmental and radiological reality of the southern Iraq marshes, but one of the most important studies was carried out by the Ministry of Water Resources / Marshlands Rehabilitation Centre in cooperation with the Ministry of Science and Technology of Iraq in 2005 to study the radioactive, chemical and microbiological contamination of selected sites of the southern Iraq marshes, The samples were measured by the system of sodium activated sodium NaI(TI) and showed that the marshland was free of any natural and industrial radioisotopes. The ratio of the natural isotope is within the limits of the sensors. The S.A concentration of Cs-137 is less than (1.2 Bq / kg) the natural radiator falls within the natural limits[8].The effects of health and radiological hazards on humans and the surrounding environment can be seen through several parameters, notably the REA (Radium Activity Parameter), which is mainly based on the natural U-238 series of the Ra-226, the Th-232 and the K-40 According to the following equation [9].

$$\mathbf{REA}\left(\frac{\mathbf{Bq}}{\mathbf{kg}}\right) = \mathbf{A_{Ra-226}}\left(\frac{\mathbf{Bq}}{\mathbf{kg}}\right) + \mathbf{1.43} * \mathbf{A_{Th-232}}\left(\frac{\mathbf{Bq}}{\mathbf{kg}}\right) + \mathbf{0.077} * \mathbf{A_{K-40}}\left(\frac{\mathbf{Bq}}{\mathbf{kg}}\right) \quad (1)$$

$A_{Ra\_226}, A_{Th\_232}, A_{K\_40}$: Radiological concentration of radium-226, thorium-232 and potassium- 40respectively.

As well as the external hazard index, which represents the effects of the natural radiation background affecting the human body externally and the internal hazard index,which represents the internal effects on the human from the natural radiation background and as in the equivalent of radium activity [9] and according to the following equations:

**$H_{int}$: Internal Hazard Index**

$$\mathbf{H_{int}} = \frac{\mathbf{A_{K-40}}}{\mathbf{4810}} + \frac{\mathbf{A_{Th-232}}}{\mathbf{259}} + \frac{\mathbf{A_{Ra-226}}}{\mathbf{185}} \quad (2)$$

**$H_{ext}$: External Hazard Index**

$$\mathbf{H_{ext}} = \frac{\mathbf{A_{K-40}}}{\mathbf{4810}} + \frac{\mathbf{A_{Th-232}}}{\mathbf{259}} + \frac{\mathbf{A_{Ra-226}}}{\mathbf{185}} \quad (3)$$

In general, if the amount of the internal or external hazard index is more than one, it indicates that there is a significant hazard to the environment and the human and must be avoided or work to remove themfor the purpose of computation of the human equivalent dose (H), the percentage of air intake that can be calculated at 1m above the Earth's surface must be calculated according to equation (4)[10].

$$\mathbf{D_{air}}\left(\frac{\mathbf{nGy}}{\mathbf{h}}\right) = \mathbf{0.427} * \mathbf{A_{Ra-226}}\left(\frac{\mathbf{Bq}}{\mathbf{kg}}\right) + \mathbf{0.662} * \mathbf{A_{Th-232}}\left(\frac{\mathbf{Bq}}{\mathbf{kg}}\right) + \mathbf{0.034} * \mathbf{A_{K-40}}\left(\frac{\mathbf{Bq}}{\mathbf{kg}}\right) \quad (4)$$

The units of $D_{air}$ are nGy / h and using the conversion coefficient of the Sv unit to the Gray unit and the factor of acquisition (representing the ratio of what the human can absorb from the absorbed dose in
the air, the H equivalent of H can be calculated from equation (5) [10].

$$\mathbf{H}\left(\frac{\mathbf{nGy}}{\mathbf{h}}\right) = \mathbf{0.2} * \mathbf{8760(h)} * \mathbf{0.7}\left(\frac{\mathbf{Sv}}{\mathbf{Gy}}\right) * \mathbf{D_{air}}\left(\frac{\mathbf{nGy}}{\mathbf{h}}\right) \quad (5)$$

0.2: occupancy Factor
0.7: Conversion factor from Sv to Gray (Sv / Gy)
$D_{air}$ : Absorbed dose rate in air

## II. Materials And Methods

The gamma spectrometer system, containing the 2keV high-purity coaxial germanium (HpGe) at the 1333keV power line of the Co-60 and 30% efficiency, was statistically analysed using the Genie 2000analysis program [11], which takes into account the system's confidence in radioisotopes. Samples were taken from the surface of the mullet bottom of different sites and weighed 1 kg and dried and cleaned from plankton and then grinded and prepared for measurement. The samples immediately aftercollection for the purpose of detecting the half-life isotopes from cosmic rays such as Be- 7.The samples then left a period of time to reach the equilibrium (Secular Equilibrium) required when examining the natural radiation activity. Taking the measurement time to be more than ten times from the radiation background of the laboratory, which was subtracted from the total count of the system for any sample.

## III. Results And Discussion

The samples of the sediments collected from the marshes of the three southern governorates of Maysan, Basra and DhiQar were examined to measure and study the radiation activity of the natural needs present in them and to find out which models contain higher radiation activity and measure the internal and external hazard index and the search for aerial and industrial radionuclides such as Be-7 and Cs-137. Table 1 shows the coding of samples and the sites collected from them.The results showed that the SS6 sample had the highest specific activity concentration of Ra-226equal to 35.2 Bq/kg. This sample represents the province of Maysan, which was exposed to large contamination ofthe uranium radiation background of U-238, while the lowest value in the sample SS8and the specific activity concentration of the isotope was 16.81Bq / kg. This sample represents the deposits of Euphrates River in the province of DhiQar, which is exclusively the participation of the natural radiation background resulting from U-238 and in general the rate S.Aconcentration In the United States of America was 35 Bq / kg and the Hong Kong average was 84 Bq / kg while Thailand recorded the highest rate of 114 Bq / kg [12, 13]. The results of the specific activity concentration of Ra-226 shown in Table 2. We note from the table that the Ra-226 concentration differs from one region to another. In general, all specific activity concentrations were within permissible levels and Figure 1illustrates S.A for Ra-226.

**Table1: Coding of sampling Location**

| NO | Sample Location | Sample Code |
|---|---|---|
| 1 | Shatt al-Arab / Basra | SS1 |
| 2 | Hor Al-batbat or the river of Al-Salam (Al-Baitra) / Maysan | SS2 |
| 3 | City Center or Tigris River (Awasha) / Maysan | SS3 |
| 4 | Hor Al-Akhr (Al-Kahla) / Maysan | SS4 |
| 5 | Hororewes (Al-khala) / Maysan | SS5 |
| 6 | River Tigris / Maysan | SS6 |
| 7 | Gharraf River / DhiQar | SS7 |
| 8 | Euphrates River / DhiQar | SS8 |
| 9 | Hollandian River / DhiQar | SS9 |

**Table 2:The results of (S.A) concentration of Ra-226**

| Sample's Code | S.A Ra-226(Bg/kg) |
|---|---|
| SS1 | 23.50 |
| SS2 | 25.27 |
| SS3 | 19.60 |
| SS4 | 22.90 |
| SS5 | 23.30 |
| SS6 | 35.20 |
| SS7 | 30.04 |
| SS8 | 16.81 |
| SS9 | 18.90 |
| Average | 23.95 |

**Table3:The results of (S.A) concentration of Ac-228**

| Sample's Code | S.A Ra-228(Bg/kg) |
|---|---|
| SS1 | 12.60 |
| SS2 | 9.80 |
| SS3 | 10.80 |
| SS4 | 12.27 |
| SS5 | 16.40 |
| SS6 | 12.20 |
| SS7 | 12.30 |
| SS8 | 9.29 |
| SS9 | 12.04 |
| Average | 11.97 |


**Fig.1:**The radiological specific activity (SA) of Ra-226 isotope as a function of sediment sample location

As for the Th-232 series, which is in secular equilibrium with Ac-228, the results of their specific activity concentrations were lower than the results of the U-238 series. This supports the presence of depleted uranium, which in addition to the natural U 238- In the SS5 sample, which is the Hororewes (Al-khala) region in Maysan, while the lowest value was in the SS8 sample at 9.29Bq / kg and the sample concentration rate was 11.97Bq / kg.And again, the concentration of the Ac-228 ratio was 64 Bq / kg and in Russia 30Bq / kg while the highest in Malaysia was 82Bq / kg [13]. All samples for Ac-228 are shown in Table 3 and Figure 2 shows the specifications activity of the Ac-228isotope in the sediment models.

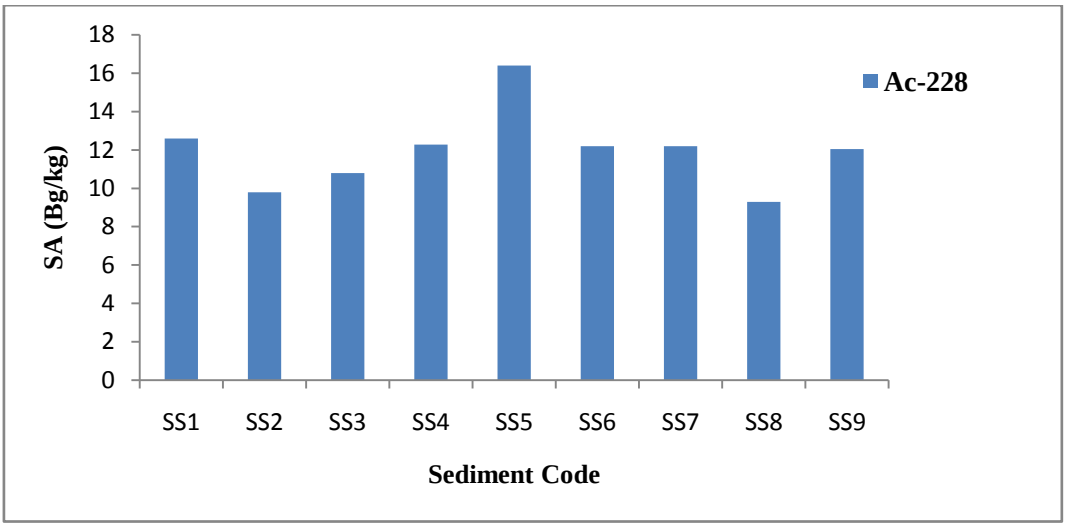


**Fig.2:** The radiological specific activity (SA) of Ac-228 isotope as a function of sedimentsample location

**Table 4: The results of (S.A) concentration of K-40**

| Sample's Code | SA K-40 (Bg/kg) |
|---|---|
| SS1 | 235.3 |
| SS2 | 218.7 |
| SS3 | 229.2 |
| SS4 | 263.6 |
| SS5 | 320 |
| SS6 | 272.7 |
| SS7 | 254.3 |
| SS8 | 245.55 |
| SS9 | 212.8 |
| Average | 250.24 |

**Table 5: The results of (S.A) concentration of Cs-137**

| Sample's Code | SA Cs-137 (Bg/kg) |
|---|---|
| SS1 | 3.3 |
| SS2 | 1.48 |
| SS3 | B.D.L |
| SS4 | 0.64 |
| SS5 | B.D.L |
| SS6 | 3.6 |
| SS7 | 0.71 |
| SS8 | 0.47 |
| SS9 | B.D.L |
| Average | 1.13 |

In Pakistan, the concentration rate was 562 Bg/kg and in China 440 Bq / kg and highest in Portugal 840 Bq / kg. [13].The highest value of the sample was SS5 at concentration 320Bq / kg and the lowest value in the sample SS9 at concentration 212.8Bq / kg. The measured potassium values here are indicative of the low concentrations of uranium in general because they are known [12]. The decrease in potassium concentration increases the uptake of uranium from marine organisms and plants because these organisms prefer potassium salt, which is relatively light on heavy salts such as uranium salt and K -40 are shown in table 4 and Figure 3 shows the specific activity of K-40 in sediment models.

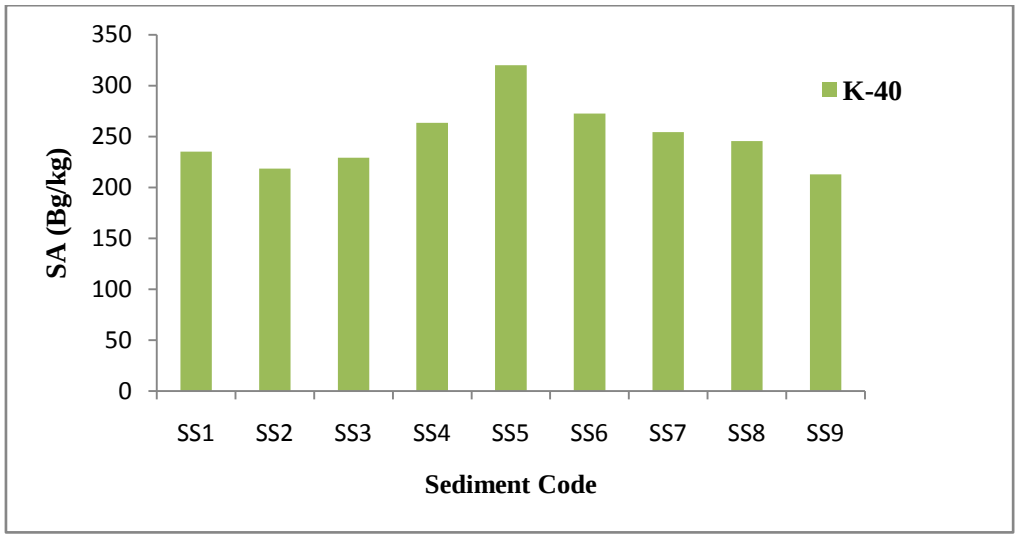


**Fig.3:** The radiological specific activity (SA) of K-40 isotope as a function of sedimentsample location

A number of sediment samples showed a few concentrations of the Cs-137, which is usually produced from nuclear fission reactions. Although these concentrations are low, they are an indicator of the transmission of this counterpart from neighboring countries by rivers. The highest value of sampleSS1is 3.3Bq / kg, while the SS3, SS5, and SS9 sites were shown below the sensitivity level of the device (B.D.L). Table 5 shows the specific radiation activity of the Cs-137 spectra of the selected sediment and Figure 4 shows the specific efficacy of Cs-137 in the sediment models:

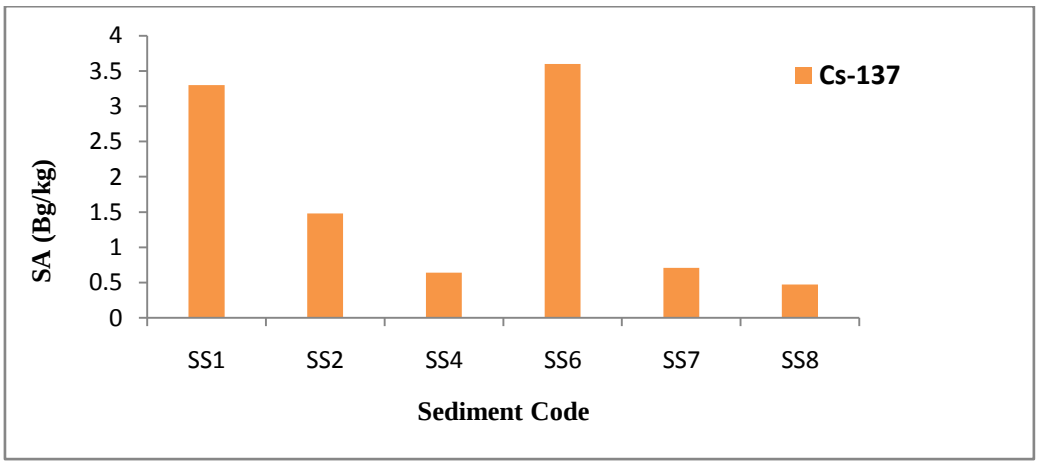


**Fig.4:**The radiological specific activity (SA) of Cs-137 isotope as a function of sedimentsample location

The SS9 showed the presence of Be-7 and 6.1Bq / kg of all the studied samples. It is known that this is the result of solar activity and the interactions of the cosmic nuclear particles with the atmospheric layer. Although the short half-life of this isotope (53.3 days) is good for the occurrence of this solar activity and thus can be adopted as such results as evidence of the occurrence of this solar activity and study and the concentration that was measured is within the natural levels [14].Table 6 show the results of these parameters and we note from this table that the highest value of the radium activity equivalent is in the sample SS6 This is obvious because the highest value of the concentration of Ra -226 was in this sample while the lowest value was in the SS8 sample for the same reason above, We conclude once again that this proven effect on the effect of radium activity and non-impact of the Th-232 and K-40 and its effect exclusively on the Ra-226 is conclusive evidence of an increase in the concentration of U-238, which is the parent nucleus of Ra-226, Depleted uranium in sediment samples either for the same time $H_{int}$ was the highest value in SS6 (0.294) while the lowest value was SS8 (0.178). For $H_{ext}$ the highest value was in SS5 (0.193) and the lowest value.The sample SS8 (0.132) and also note that there is a convergence of values for all samples and generally note an increase in the internal risk factor of the external risk factor, which is normal because the effects of internal radiation are more

dangerous and more influential than the effects of external radiation. The ratio of the human dose, which is also an important parameter in the measurement of human radiation hazard, which is mainly based on the $D_{air}$, was the highest in SS6 (39709nGy / h) and the lowest value of sample SS8 (26584nGy / h).Again, we observe the effect of these parameters by increasing the concentration of the Ra-226 equivalent of the U-238 series, which is the primary isotope of depleted uranium.Figures 5, 6 show the equivalent of radium activity in sediment and Increase internal hazard index on the external.In general and for all of the equations above, the secular equilibrium of the eternity was used for the chains. The Ra-226 was adopted as an approximation of the U-238 isotope and the Ac-228 as an approximation of the Th-232.

**Table 6:** Shows the results of REA,$D_{air}$, H,$H_{int}$,$H_{ext}$

| Sample's Code | REA (Bq/kg) | (nGy/h) | H (nGy/h) | | |
|---|---|---|---|---|---|
| **SS1** | **55.49** | **26.38** | **32347** | **0.225** | **0.161** |
| **SS2** | **59.06** | **26.07** | **31973** | **0.228** | **0.160** |
| **SS3** | **49.83** | **23.31** | **28589** | **0.195** | **0.135** |
| **SS4** | **60.74** | **26.86** | **32945** | **0.226** | **0.164** |
| **SS5** | **69.53** | **31.69** | **38860** | **0.256** | **0.193** |
| **SS6** | **73.64** | **32.38** | **39709** | **0.294** | **0.181** |
| **SS7** | **67.21** | **29.62** | **36321** | **0.262** | **0.182** |
| **SS8** | **49.00** | **21.68** | **26584** | **0.178** | **0.132** |
| **SS9** | **52.50** | **23.28** | **28546** | **0.193** | **0.142** |
| **Average** | **59.66** | **26.80** | **32874.96** | **0.228** | **0.161** |

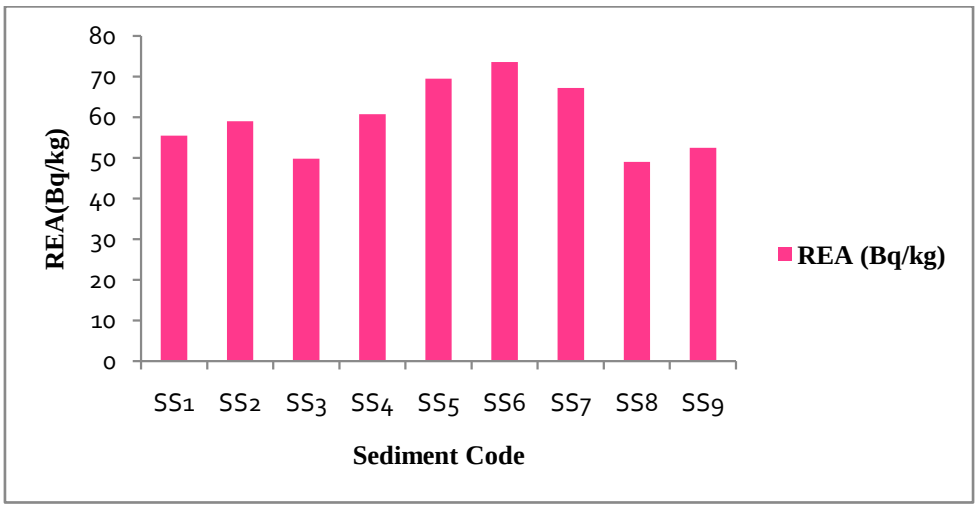


**Fig.5:**The equivalent of the radium activity in Bq/kg in sediments

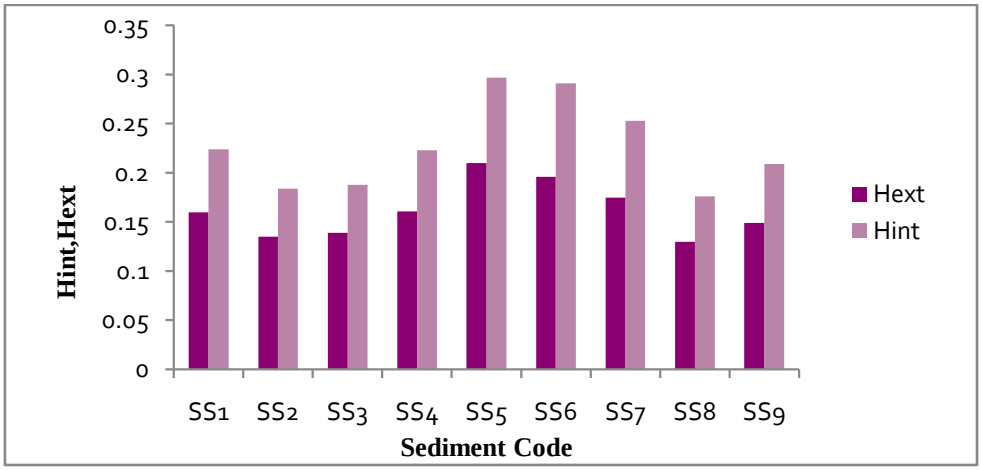


**Fig .6:** Increase internal hazard index on the external

## IV. Conclusions

The results of this study showed that the SS6 sample, which is composed of sediments collected from an estuary of the Tigris in HorAl-Hawizah in Maysan Governorate, represents the highest values of the results of the specific radiation efficiency calculations, the equivalent of the radium activity, the absorbed dose in the air and the internal hazard index, while the SS8 sample, Of the estuaries of the Euphrates river in the HorAl-Hamar in the province of DhiQar the lowest values. Some samples showed radiation concentrations of Cs-137 and the highest concentration was also in SS6. In general, all results were within internationally permitted natural levels such as the World Environment Organization [2], the European Environmental Protection Organization [9] and the World Health Organization. [10]

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IOSR Journal of Applied Physics (IOSR-JAP) is UGC approved Journal with Sl. No. 5010, Journal no. 49054.

Hiba M. Salim Al-Hameed"Measurement of Radioactivity In Marsh Sediments of South Iraq." IOSR Journal of Applied Physics (IOSR-JAP) , vol. 10, no. 3, 2018, pp. 43-49.