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# Natural Radioactivity Measurement in Surface Soil Samples Collected from Qadissia district (Alaskan Alssinaey) inNassiriyah City, Thi-Qar province, Iraq

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**Abstract**

People are being continuously exposed to ionizing radiations, there are many sources of radiation and radioactivity in the environment, radioactivity may be natural and artificial. The total amount of radioactivity in an environment should be accurately known and kept to a level as low as reasonably achievable.

Laboratory based NaI(Tl) detector Gamma ray spectroscopy system was exploited to determine distribution of gamma emitting radionuclides (238U, 232Th and 40K) in surface soils for 21 locations within Qadissia district in Nassiriyah city, Thi-Qar province, Iraq. These sites were marked-out using Global Positioning System (GPS.(

The measured activity concentrations ranged from 26.03 ± 3.22 to 33.82 ± 5.32 (30.41 ± 4.28) Bq/kg for 238U, 19.76 ± 2.01 to 28.11 ± 3.16 (24.79 ± 3.23) Bq/kg for 232Th and 277.86 ± 11.86 to 368.92 ± 19.84 (316.51 ± 15.95) Bq/kg for 40K, with mean values enclosed in the brackets. The lowest value of Radium equivalent activity is 77.59 Bq/kg, while the highest value is 102.01 Bq/kg, with average value 90.24 Bq/kg, and the absorbed dose rate varied between 36.06 to 47.17 nGy/h, with an average value of 41.68 nGy/h. Also, in the present work are measured both (external and internal) hazard indices, they ranged from 0.209 to 0.275 with an average of 0.243, and from 0.279 to 0.365 with an average of 0.325 respectively. All the results that were obtained were within the permissible limits and in accordance with recent recommendations from the United Nations Scientific Committee on the Effect of Atomic Radiation (UNSCEAR).

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**Key Words**: Natural Radioactivity, Gamma-Ray Spectrometry, NaI(Tl), Specific Activity.

# قياس النشاط الإشعاعي الطبيعي في عينات التربة السطحية لحي القادسية (الإسكان الصناعي) في مدينة الناصرية, محافظة ذي قار, العراق

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**الخلاصة**

يتعرض الناسباستمرارلإشعاعاتالمؤينة،وهناكالعديدمنمصادرالإشعاعوالنشاطالإشعاعيفيالبيئة،قديكونالنشاطالإشعاعيطبيعيواصطناعي. المقدار الكليهنالنشاطالإشعاعيفيالبيئةيجبأنيكونمعروفابدقةوحفظهعندمستوىمنخفضعنالحدالمسموح.

استخدمت منظومة كاشف NaI(Tl)مختبرية لتحديدالنويداتالمشعة ( $^{238}U$, $^{232}Th$ و$^{40}K$)الباعثةلأشعةجامافيالتربةالسطحيةلإحدى وعشرونعينةمن مواقع مختلفة فيحيالقادسيةفيمدينةالناصرية،محافظةذيقار،العراق . هذهالمواقعحددت باستخدامنظامتحديدالمواقعالعالمي(GPS).

قيم تركيزالنشاطالمحسوبتتراوح من 26,03 ± 3,22إلى33,82 ± 5,32 (30,41 ± 4,28) بيكريل/كغمل$^{238}U$ ومن19,76 ± 2,01إلى28,11 ± 3,16 ( 24,79 ± 3,23) بيكريل/كغمل$^{232}Th$ومن277,68 ± 11,86إلى368,92 ± 19,84 ( 316,51 ± 15,95) بيكريل/كغمل$^{40}K$،معمتوسط القيمفيالأقواسالمغلقة. أقلقيمةمرتفعكافئ نشاط الراديومهي 77,59 بيكريل/كغم،بينماأعلىقيمة 102,01 بيكريل/كغم،معمتوسط قيمة 90,24 بيكريل/كغم،ومعدلالجرعةالممتصةتنوعتبين 36,06 إلى 47,17 نانو كري/ ساعة،معمتوسط قيمة 41,68نانو كري/ساعة. لذلك, في الشغل الحالي تمقياسكلامؤشراتالمخاطر(الخارجيةوالداخلية)وتراوحتمن 0,209 إلى 0,275بمتوسط 0,243ومن 0,279 إلى 0,365بمتوسط 0,325علىالتوالي.

كلالنتائجالتي تم الحصول عليها كانت ضمن الحدود المسموح بها وفقاللتوصياتالأخيرةمناللجنةالعلميةللأممالمتحدةعلىتأثيرالإشعاعالذري (اليونسير).

## 1. Introduction

People are being continuously exposed to ionizing radiations, there are many sources of radiation and radioactivity in the environment. The earth and atmosphere contain varied levels from naturally radionuclides such as $^{238}U$ and $^{232}Th$ decay chains as well as singly occurring types such as $^{40}K$. Soil features, geological formations, and human activities related to radiation and radioactivity are important factors enhancing the background levels of natural radiation *Colmenero S. et al. (2004).*

Radioactivity may be natural and artificial. Natural radio-activity occurs due to extraterrestrial sources as well as from radioactive elements in the earth's crust. Artificial radioactivity may be released into the environment during the normal operations of nuclear facilities and installations such as nuclear ore processing, uranium enrichment, fuel and oil fabrication, reactor operations and application of radioisotopes in the fields of nuclear medicine, research, industry and agriculture *Kabir K. A. et al. (2009).*A large amount of radiation releases due to accident of nuclear reactor (the Chernobyl power plant accident) and the routine discharge of radionuclides from nuclear installations *Ahmad, N., et al. (1997).*

These emissions are very small in normal operation, although large amounts of radioactivity could be released to the environment through accidents. The total amount of radioactivity in an environment should be accurately known and kept to a level as low as reasonably achievable. Exposures from natural radiation are the largest component of all

exposures for most people, and form the baseline upon which exposures from manmade sources are added *UNSCEAR(2000).*

UNSCEAR suggested median values for $^{238}U$, $^{232}Th$ and $^{40}K$ of (35, 30 and 400) Bq/kg respectively, based on corresponding dose coefficients of (0.0417, 0.462 and 0.604) nGy/h per Bq/kg. Although several studies in the literatures present data about the radioactivity in Iraqi environmental, no information is available on annual effective dose of $^{238}U$, $^{232}Th$ and $^{40}K$ from oil fabrication and its impact on nearby residential communities.

The overall aim was to investigate the concentrations of some long lived radionuclides ($^{238}U$, $^{232}Th$ and $^{40}K$) in surface soil samples for Qadissia district inhabitants (Alaskan alssinaey), which is located near Nassiriyah oil depot in Thi-Qar province, to provide data that should help improve the technology of radioactivity analysis and draw radiological map, which will serve as reference to estimate health hazard index due to radiation exposure for this region in the future, as well as people's health and environment.

## 2. Materials and Methods

1- **Site :**

The study site is located at ($31^{o}00'19.10''$ N and $46^{o}17'23.25''$ E) using the Google Earth, as shown in figures (1,2). The monitoring points includes twenty one locations within Qadissia district in Nassiriyah city, Thi-Qar province, Iraq. These sites were marked-out using Global Positioning System (GPS).

2- **The samples preparation**

After the surface soil samples collected from the study site. The samples were ground to a fine grain powder with a particle size less than 600 µm using mechanical crusher. Afterwards, they were dried at (120C°) in an oven for 24 hours to eliminate any traces of water, then the powdered samples were stored in tight plastic containers more than four weeks to achieve the secular equilibrium.

3- **Gamma-ray Detection system**

Gamma-ray spectroscopy system provides practical way to characterize dispersed radionuclides in the soil to ascertain possible changes in the environmental radioactivity. laboratory gamma spectroscopy is often used for monitoring and assessment of radioactivity and radiation dose rates in the environment due to both natural and anthropogenic sources *Beck, H. L et al. (1972), Clouvas, X. et al. (2001).*

NaI(TI) detector (3"x 3")inch type was employed for the gamma-ray spectrometry measurements. The power supply and the data acquisition of the energy spectra were achieved by using an integrated spectroscopy system from ORTEC. The system utilized MAESTRO-32 (version 6.06) software package from the same company. The detector has an energy resolution of about 7.6% at 662 keV of $^{137}$Cs and operation bias voltage (720-1200 Volt) DC. Each sample was counted for a period of 5 hours (18000 sec).

Under the assumption that secular equilibrium was reached between $^{232}$Th and $^{238}$U ($^{226}$Ra) with their decay products, those at 1.760 MeV peak from $^{214}$Bi and 2.614 MeV from $^{208}$TI were used for the measurement of $^{238}$U ($^{226}$Ra) and $^{232}$Th, respectively. While the single photopeak at 1.460 MeV was used for the measurement of $^{40}$K (directly gamma-emitter). Background activities for the three selected energies were subtracted from the sample's readings in order to assess the true activities of each isotope. And to reduce the gamma-radiation background, the detector is surrounded by a 5cm thick lead shield.


**Figure 1. Satellite image that showing the sampling points includes twenty one locations within Qadissia district(Alaskan alssinaey) in Nassiriyah city, Thi-Qar province.**


**Figure 2. Satellite image that showing Qadissia district (Alaskan alssinaey), which is located near Nassiriyah oil depot in Thi-Qar province.**

## 3. Calculation of Radiological Effects

### 1-Specific Activity (A) :

The specific activity (Activity Concentration) of the detected radionuclides were be calculated by using the equation 1. *Harb S. et al. (2008)*:

$$A_i = \frac{N}{I_\gamma . \varepsilon . m . t} \quad \ldots(1)$$

Where $A_i$(Bq/kg) : the specific activity of the i radionuclides, N : is the net area under the peak, $I_\gamma$ : the absolute transition probability of γ-decay, ε : the detector efficiency for the specific γ-ray energy, m(kg) : the mass of sample and t (sec) : the time of measurement.

2- **Radium Equivalent Activity ($Ra_{eq}$) :**

Circulation of $^{238}U$, $^{232}Th$ and $^{40}K$ in environment is not the same, Generally, exposure of radiation spread from these radionuclides has been defined in terms of radium equivalent activity ($Ra_{eq}$) in Bq/kg to compare the specific activity of substances containing different amounts of $^{238}U$, $^{232}Th$ and $^{40}K$*Ya-xin Y. et al. (2005).*

An index called the (Radium equivalent activity) to get the sum of activities for comparison of the specific radio-activities of substances containing different radionuclides like $^{238}U$($^{226}Ra$), $^{232}Th$ and $^{40}K$. It has been credible that 370 Bq/kg of $^{226}Ra$, 260 Bq/kg of $^{232}Th$ and 4810 Bq/kg of $^{40}K$ produce the equivalent γ- ray dose rate. Thus the radium equivalent activities ($Ra_{eq}$) were calculated through the equation 2. *Ya-xin Y. et al. (2005), European Commission (1999)*:

$$Ra_{eq} = A_U + 1.43A_{Th} + 0.077A_K \quad \ldots (2)$$

Where, $A_U$, $A_{Th}$ and $A_K$ are thespecific activities of$^{238}U$, $^{232}Th$ and $^{40}K$ respectively.

3-**Absorbed Gamma Dose Rate ($D_\gamma$) :**

Absorbed gamma dose rate ($D_\gamma$) in air at 1 m above the ground level has been calculated with the equation 3. *European Commission (1999)*:

$$D_\gamma = 0.462A_U + 0.604A_{Th} + 0.04A_K \quad \ldots (3)$$

where 0. 46, 0.604 and 0.04 (nGy/h per Bq/kg) are the dose conversion factors for $^{238}U$, $^{232}Th$ and $^{40}K$ respectively.

4-**External Hazard Index($H_{ex}$) and Internal Hazard Index($H_{in}$):**

External hazard index($H_{ex}$) and internal hazard index ($H_{in}$) of each samples are given by following two equations respectively *Elham S. et al. (2012)*:

$$H_{ex} = \frac{A_U}{370} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \leq 1 \quad ...(4)$$

$$H_{in} = \frac{A_U}{185} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \leq 1 \quad ...(5)$$

For the safety, the value of this index must be less than unity in order to keep the radiation hazard insignificant. The maximum value of hazard index equal to unity corresponds to the upper limit of Radium equivalent activity (370 Bq/kg)*UNSCEAR(2000), Harb S. et al. (2008).*

**4. Results and Discussion**

The results of measurements for 21 surface soil samples collected at different locations in Qadissia district are presented in Table 1. and Table 2. .

Table 1. shows the value of radionuclide concentrations of $^{238}U$, $^{232}Th$and$^{40}K$ beside the calculated Radium equivalent activity ($Ra_{eq}$). It can be noticed that from this table the concentrations range from 26.03 ± 3.22 in sample (S3) to 33.82 ± 5.32 recorded in sample (S7) (30.41± 4.28) Bq/kg for $^{238}U$, 19.76 ± 2.01 in sample (S3) to 28.11 ± 3.16 recorded in sample (S21) (24.79± 3.23) Bq/kg for $^{232}Th$ and 277.86 ± 11.86 in sample (S12) to 368.92 ± 19.84 recorded in sample (S21) (316.51± 15.95) Bq/kg for $^{40}K$, with mean values enclosed in the brackets.

Also the table 1. shown that the specific activity of potassium-40 is higher thanthe specific activity of Uranium-238 and the specific activity of Thorium-232 is lower than in both of them for all samples. The value of specific activity of $^{238}U$, $^{232}Th$ and $^{40}K$ for all surface soil samples be positioned in the range of the worldwide average 35, 30 and 400 Bq/kg respectively *UNSCEAR(2000)*.

The (±) values related to the mean values correspond to the variability (standard deviation) in the specific activity values of the radionuclide.

Finally, the table 1. reveal that the lowest value of Radium equivalent activity ($Ra_{eq}$) is77.59 Bq/kg calculated in sample (S3) while the highest value is 102.01Bq/kg in sample (S21), with average value 90.24Bq/kg.All values of($Ra_{eq}$) appear less than the worldwide average and European permissibility limit(370Bq/kg and 247 Bq/kg)respectively*European Commission (1999),UNSCEAR(2008)*.

From the obtained results in the table 2. it can be seenthat theabsorbed dose rate varied between 36.06 to 47.17 nGy/h,with an average value of 41.68 nGy/h, which is less than the global limit (55 nGy/h) *UNSCEAR(2008)*.

Also, the results listed in the table 2. showed that the external hazard index ranged from 0.209 to 0.275 with an average of 0.243, and the internal hazard index ranged from 0.279 to 0.365 with an average of 0.325. All values for both hazard indices are lower than the permissibility value*UNSCEAR(2008)*.

Figure 3. appear a comparison of the activity concentrations (Uranium-238, Thorium-232 and Potassium-40) for all surface soil samples in the present work with the recent regulations average values of each radionuclide.

Figure 4. reveal to a comparison of Radium equivalent activity and absorbed dose rate for all surface soil sampleswith the worldwide average of each one represented by the blue line for global limit for($Ra_{eq}$) and red line forworldwide average for($D_\gamma$).

Figure 5. shows a comparison of hazard indices (External and Internal)all surface soil samples in the present work with the acceptable global limit(unity) represented by the red line.

**Table 1.**The Specific Activity of ($^{238}U$, $^{232}Th$ and $^{40}K$) Radionuclidesand Radium Equivalent Activity of the Surface Soil Samples.

| **Code of Sample** | **Specific Activity (Bq/Kg)** | | | **$Ra_{eq}$ (Bq/Kg)** |
|---|---|---|---|---|
| | **$^{238}U$** | **$^{232}Th$** | **$^{40}K$** | |
| **S1** | **31.04 ± 5.18** | **25.93 ± 4.67** | **287.28 ± 19.06** | **90.24** |

| | | | | |
|---|---|---|---|---|
| **S2** | **31.69 ± 4.99** | **26.03 ± 4.46** | **301.07 ± 17.98** | **92.09** |
| **S3** | **26.03 ± 3.22** | **19.76 ± 2.01** | **302.64 ± 11.47** | **77.59** |
| **S4** | **30.7 ± 3.51** | **23.81 ± 2.78** | **318.88 ± 13.41** | **89.30** |
| **S5** | **31.16 ± 3.96** | **25.13 ± 3.39** | **324.58 ± 20.14** | **92.08** |
| **S6** | **32.07 ± 4.83** | **25.24 ± 3.87** | **317.97 ± 18.59** | **92.64** |
| **S7** | **33.82 ± 5.32** | **27.06 ± 4.36** | **335.59 ± 12.76** | **98.35** |
| **S8** | **30.29 ± 4.27** | **24.12 ± 2.75** | **306.15 ± 14.43** | **88.35** |
| **S9** | **28.93 ± 3.89** | **21.78 ± 1.91** | **321.76 ± 19.71** | **84.85** |
| **S10** | **29.08 ± 4.95** | **26.84 ± 5.11** | **318.92 ± 17.26** | **92.01** |
| **S11** | **30.11 ± 5.05** | **23.04 ± 3.61** | **289.05 ± 18.09** | **85.31** |
| **S12** | **27.45 ± 1.75** | **22.17 ± 2.09** | **277.86 ± 11.86** | **80.54** |
| **S13** | **27.99 ± 2.16** | **24.03 ± 3.34** | **304.83 ± 15.56** | **85.82** |
| **S14** | **30.35 ± 3.79** | **26.25 ± 3.99** | **293.02 ± 14.73** | **90.45** |
| **S15** | **31.67 ± 4.41** | **25.73 ± 4.13** | **313.42 ± 13.88** | **92.59** |
| **S16** | **30.53 ± 4.35** | **24.33 ± 3.03** | **301.5 ± 12.49** | **88.53** |
| **S17** | **29.18 ± 3.57** | **22.81 ± 2.89** | **317.19 ± 13.03** | **86.22** |
| **S18** | **28.62 ± 3.61** | **24.49 ± 1.47** | **335.06 ± 17.61** | **89.44** |
| **S19** | **32.09 ± 5.13** | **26.05 ± 2.55** | **359.84 ± 16.44** | **97.05** |
| **S20** | **32.54 ± 6.02** | **27.94 ± 2.29** | **351.33 ± 16.67** | **99.54** |

| | | | | |
|---|---|---|---|---|
| **S21** | **33.41 ± 5.93** | **28.11 ± 3.16** | **368.92 ± 19.84** | **102.01** |
| **Minimum** | **26.03 ± 3.22** | **19.76 ± 2.01** | **277.86 ± 11.86** | **77.59** |
| **Maximum** | **33.82 ± 5.32** | **28.11 ± 3.16** | **368.92 ± 19.84** | **102.01** |
| **Average** | **30.41± 4.28** | **24.79± 3.23** | **316.51± 15.95** | **90.24** |

**Table 2.**Absorbed Dose Rate and Hazard Indices (External and Internal) of the Surface Soil Samples.

| Code of Sample | $D_\gamma$ (nGy/h) | $H_{ex}$ | $H_{in}$ |
|---|---|---|---|
| **S1** | **41.49** | **0.243** | **0.327** |
| **S2** | **42.41** | **0.248** | **0.334** |
| **S3** | **36.06** | **0.209** | **0.279** |
| **S4** | **41.32** | **0.241** | **0.324** |
| **S5** | **42.55** | **0.248** | **0.332** |
| **S6** | **42.78** | **0.251** | **0.336** |
| **S7** | **45.39** | **0.265** | **0.357** |
| **S8** | **40.81** | **0.238** | **0.321** |
| **S9** | **39.39** | **0.229** | **0.307** |
| **S10** | **42.40** | **0.248** | **0.327** |
| **S11** | **39.38** | **0.230** | **0.311** |
| **S12** | **37.19** | **0.217** | **0.291** |

| | | | |
|---|---|---|---|
| S13 | 39.63 | 0.231 | 0.307 |
| S14 | 41.59 | 0.244 | 0.326 |
| S15 | 42.71 | 0.250 | 0.335 |
| S16 | 40.86 | 0.239 | 0.321 |
| S17 | 39.94 | 0.232 | 0.311 |
| S18 | 41.41 | 0.241 | 0.318 |
| S19 | 44.95 | 0.262 | 0.348 |
| S20 | 45.96 | 0.268 | 0.356 |
| S21 | 47.17 | 0.275 | 0.365 |
| Minimum | 36.06 | 0.209 | 0.279 |
| Maximum | 47.17 | 0.275 | 0.365 |
| Average | 41.68 | 0.243 | 0.325 |

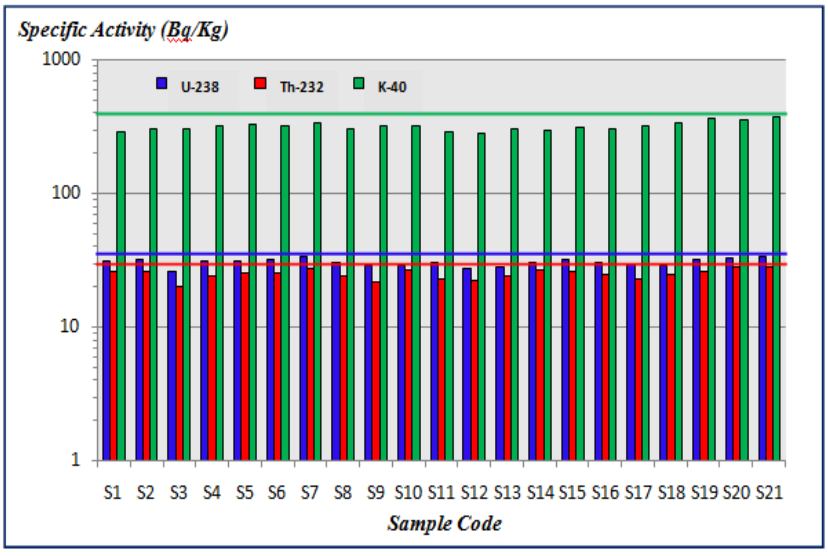

**Figure 3.**A comparison of the specific activity of ($^{238}$U, $^{232}$Th and $^{40}$K) radionuclides of surface soil samples with the recent regulations average values of each radionuclide.

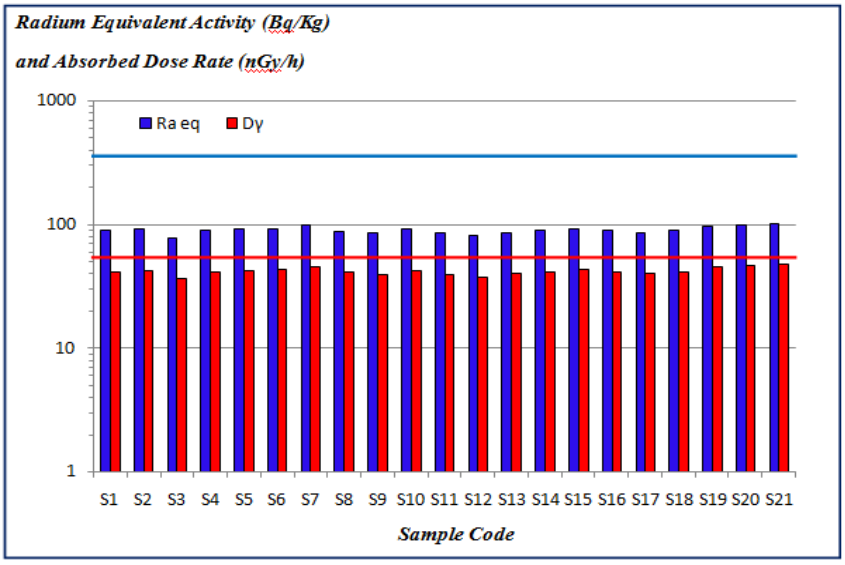


**Figure 4.**A comparison of Radium equivalent activity and absorbed dose rate for all surface soil samples with the worldwide average of each one.

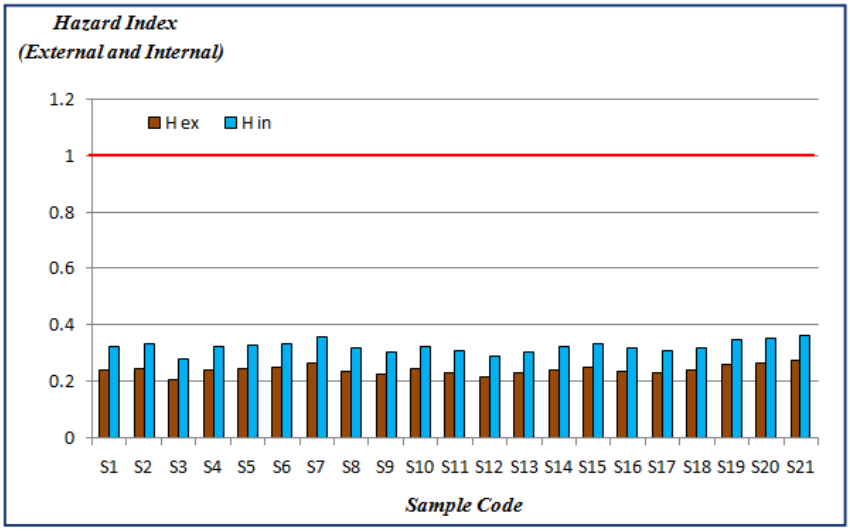


**Figure 5.**A comparison of hazard indices (external and internal) for all surface soil samples with the global limit (unity).

## 5. Conclusions

Laboratory based NaI(Tl) detector system was exploited to determine distribution of gamma emitting radionuclides ($^{238}$U, $^{232}$Th and $^{40}$K) in surface soils for Qadissia

district in Nassiriyah city, Thi-Qar province, Iraq. This technique is useful to draw radiological map, which will serve as reference to estimate health hazard index due to radiation exposure for this region in the future.

The results in the present work indicate that the area under investigation has different activity concentrations for each one of radionuclides according to the locations of the sample point.

In general :

1- all radiometric results were safety according to the recent recommendations from United Nations Scientific Committee on the Effect of Atomic Radiation*UNSCEAR(2000)and(2008)*.

2- No artificial radionuclides were detected in theselected surface soil samples which is collected from(Alaskan alssinaey)neighborhood locate near the construction of Nassiriyah oil depot, this refer that the oil depot has no significant impact on the radiation burden of environment.

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