# Determination and Mapping of Activity Levels of $^{40}$K in Madloom Region in Al-Najaf Al-Ashraf

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**Abstract**

Ninety nine soil samples were collected from Madloom region in Al-Najaf Al-Ashraf. The gamma rays spectral measurements were done for all samples by using Sodium Iodide activated by Thalium NaI(Tl), its dimension 2"× 2", from the spectral analysis identified Potassium $^{40}$K radionuclide. The activity concentration was calculated for $^{40}$K, ranged from 66.53±1.39 Bq.Kg$^{-1}$ to 225.32±2.84 Bq.Kg$^{-1}$, and the mean value were 142±2.16 Bq.Kg$^{-1}$.

# قياس ورسم خارطة لمستويات الفعالية للبوتاسيوم $^{40}$K في منطقة مظلوم في النجف الأشرف

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**الخلاصة**

جُمع 99 نموذج تربة من منطقة مظلوم في النجف الأشرف وأجريت القياسات الطيفية باستخدام منظومة كاشف يوديد الصوديوم المنشط بالثاليوم NaI(Tl) الذي ابعاده "2×"2، ومن نتيجة التحليل الطيفي تم تشخيص نويدة البوتاسيوم $^{40}$K. حُسب تركيز الفعالية للبوتاسيوم $^{40}$K فتراوح تركيز الفعالية من 66.53±1.39 Bq.Kg$^{-1}$ الى 225.32±2.84 Bq.Kg$^{-1}$ ، وكانت قيمة المعدل 142±2.16 Bq.Kg$^{-1}$.

## 1. Introduction:

Radioactive elements are generally classified into two types: Naturally occurring and artificially produced radioactive elements. Naturally occurring radioactive materials (NORM) are found in soil, building materials such as cement, granite, ceramic, stones …etc.[1]

Natural ionizing radiation is a single largest contributor to the total dose received by the human being. This arises out of natural species of radiation on the Earth crust and cosmic radiation. The natural species of radiation are the nuclides with half-lives comparable with age of the earth existing in terrestrial material. Naturally occurring radionuclides are $^{238}$U, $^{232}$Th and $^{40}$K. Many of the radionuclides formed from uranium and thorium contribute to the exposure to the human [2].

Natural environmental radioactivity and the associated external exposure due to gamma radiation depend mainly on the geological and geographical conditions, and appear at different levels in the soils of each region in the world [3].

Radioactivity of soil environment is one of the main sources of exposure to humans. Hence it is important to know its distribution, gamma radiation from radionuclides which are characterized by half-lives comparable to the age of the earth, such as $^{40}$K and radionuclides from the $^{238}$U and $^{232}$Th series. Their decay products represent the main external source of radiation to the human body. More specifically, natural radioactivity and the associated external exposure due to gamma radiation depend primarily on the geological and geographical conditions, and appear at different levels in the soil of each region in the world [4].

Ionizing radiations have sufficient energies to cause ionization in matter. When it is incident on the body, part or whole of the energy may be absorbed by the cells through the process of ionization and excitation. The excited and ionized water molecules in human tissues undergo a series of reaction resulting in the production of free radicals. These free radicals are highly reactive entities having a life time of about one micro second and attack other bio molecules such as protein, Lipids and DNA causing chemical and structural damages to these molecules [2].

## 2. Experimental Procedures:

### 2.1 Samples collection and preparation

A total of 99 soil samples were collected uniformly along the strategically road of Madhloom region . The masses of the collected samples varied between 983 and 1494 gm. The samples were grinded and crushed to fine grain size of about 100 mesh to small pieces and sieved in order to homogenize it and remove big size. The samples were then drying at sunlight to ensure that moisture is completely removed[5].

### 2.2 Measurement of Detector's Efficiency

By using , Cd-109, Co-57, Ba-133, Na-22, Cs-137, Mn-54, Co-60, as standard sources and appling the two following equations, the counting efficiency was measured.[6]

***Equation of correction***

$$C_t = C_0 \, e^{-\lambda \, t_d} \qquad (1)$$

$C_t$: Activity of (standard source) at the moment of measurement.

$C_0$: Activity of (standard source) at the moment of manufacturing. $t_d$:delay time

$\lambda$ : decay constant

$\lambda = \frac{\ln 2}{t_{1/2}} = \frac{0.693}{t_{1/2}}$ , $t_{1/2}$: half life of standard source.

***Equation of efficiency*** *(correction by eq. (1))*

$$\varepsilon\% = \frac{C'}{C_t I_\gamma} \times 100\% \qquad (2)$$

$C'$ : Activity of the photopeack at the moment of measurement with out background

$I_\gamma$ : the percent of Gamma intensity.

Table.1 Calculation of Detector Efficiency

| radionuclide | E(KeV) | Intensity(I%) [7] | $t_{1/2}$(d) | $C_t$ | $C'$ | $\varepsilon\%$ |
|---|---|---|---|---|---|---|
| **Cd-109** | 88 | 3.6 | 462.5 | 19079.89 | 98141 | 47.6268 |
| **Co-57** | 122 | 85.6 | 271.8 | 11988.7 | 571371 | 18.5589 |
| **Ba-133** | 356 | 62 | 3832.5 | 34157.93 | 613186 | 9.6513 |
| **Na-22** | 511.0034 | 170 | 949 | 26793.27 | 754899 | 5.5245 |
| **Cs-137** | 661.64 | 85.1 | 11205.5 | 36002.29 | 470251 | 5.1162 |
| **Mn-54** | 834.827 | 100 | 312.3 | 13875.31 | 192828 | 4.6324 |
| **Co-60** | 1173.2 | 99.97 | 1923.55 | 31553.29 | 149248 | 1.5771 |
| **Na-22** | 1274.5 | 99.94 | 949 | 26793.27 | 123468 | 1.537 |
| **Co-60** | 1332.5 | 99.98 | 1923.55 | 31553.29 | 132816 | 1.4034 |

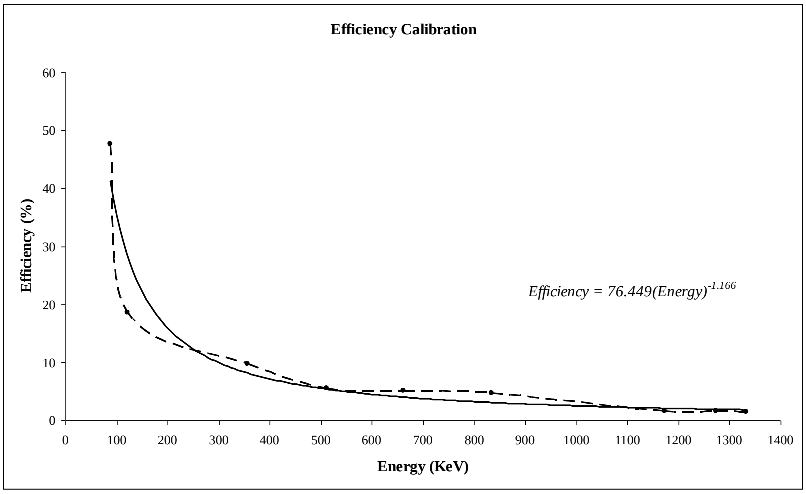


Fig .1 The efficiency of detector against energy.

In Fig. 1 the dashed curve is experimental values of efficiency and the solid curve is fitting of the curve.

From the Fig .1 the efficiency fo 1460 (KeV) was 1.50%

## 3. Results

### 3.1 Activity concentration of $^{40}K$

Gamma transitions of 1.460 MeV for $^{40}$K. The radioactivity concentration in the investigated samples was obtained as follows:

$$A = \frac{(CPS)_{net}}{I \times E_{ff} \times m} = \frac{Area\ under\ peak}{I \times E_{ff} \times m \times t} \quad (3)$$

where A is the activity concentration in Bq/kg, $(cps)_{net}$ is the (count per second), I is the intensity of the $\gamma$-line in a radionuclide, $E_{ff}$ is the measured efficiency for each $\gamma$ -line observed and m is the mass of the sample in kilograms, t is the measurements time. [8,9].

Table.2 Activity concentration of $^{40}$K

| Sample N. | $^{40}$K Bq/Kg | Sample N. | $^{40}$K Bq/Kg | Sample N. | $^{40}$K Bq/Kg |
|---|---|---|---|---|---|
| **1** | 101.43±1.82 | **34** | 189.79±2.59 | **67** | 148.87±2.17 |
| **2** | 124.71±2.05 | **35** | 186.16±2.53 | **68** | 153.97±2.30 |
| **3** | 163.85±2.33 | **36** | 175.84±2.38 | **69** | 150.51±2.23 |
| **4** | 154.68±2.33 | **37** | 97.44±1.82 | **70** | 137.89±2.03 |
| **5** | 194.31±2.64 | **38** | 155.56±2.30 | **71** | 104.62±1.74 |
| **6** | 165.85±2.37 | **39** | 156.67±2.37 | **72** | 147.36±2.04 |
| **7** | 170.29±2.58 | **40** | 174.68±2.52 | **73** | 103.12±1.89 |
| **8** | **225.33±2.84** | **41** | 128.97±2.05 | **74** | 99.41±1.88 |
| **9** | 163.34±2.41 | **42** | 159.19±2.26 | **75** | 159.29±2.26 |
| **10** | 113.60±1.84 | **43** | 172.40±2.39 | **76** | 122.70±1.93 |
| **11** | 104.34±1.83 | **44** | 165.88±2.40 | **77** | 140.30±2.08 |
| **12** | 185.30±2.48 | **45** | 133.82±2.07 | **78** | 115.77±1.90 |
| **13** | 107.74±1.87 | **46** | 111.74±1.91 | **79** | 132.58±2.05 |
| **14** | 149.62±2.20 | **47** | 122.70±2.03 | **80** | 149.71±2.30 |
| **15** | 152.79±2.32 | **48** | 122.83±1.98 | **81** | 169.43±2.39 |
| **16** | 182.72±2.54 | **49** | 143.19±2.25 | **82** | 84.88±1.60 |
| **17** | 185.74±2.43 | **50** | 162.68±2.34 | **83** | 74.52±1.59 |
| **18** | 196.27±2.63 | **51** | 119.66±1.91 | **84** | 102.36±1.79 |
| **19** | 142.14±2.17 | **52** | 167.71±2.40 | **85** | **66.54±1.39** |
| **20** | 127.91±2.06 | **53** | 148.63±2.10 | **86** | 127.19±2.01 |
| **21** | 162.38±2.52 | **54** | 146.12±2.12 | **87** | 114.55±1.89 |
| **22** | 161.38±2.35 | **55** | 105.60±1.80 | **88** | 127.17±2.00 |
| **23** | 172.80±2.44 | **56** | 96.93±1.95 | **89** | 136.48±2.04 |
| **24** | 142.28±2.11 | **57** | 135.29±2.07 | **90** | 147.64±2.13 |
| **25** | 162.13±2.44 | **58** | 109.74±1.80 | **91** | 86.93±1.69 |
| **26** | 193.94±2.55 | **59** | 153.01±2.21 | **92** | 110.74±2.01 |
| **27** | 162.34±2.36 | **60** | 152.39±2.16 | **93** | 165.00±2.48 |
| **28** | 131.65±2.17 | **61** | 151.85±2.21 | **94** | 109.81±1.94 |
| **29** | 152.97±2.29 | **62** | 168.22±2.39 | **95** | 124.89±1.96 |
| **30** | 152.22±2.30 | **63** | 146.91±2.14 | **96** | 120.90±1.90 |
| **31** | 159.58±2.39 | **64** | 142.17±2.46 | **97** | 108.79±1.78 |
| **32** | 179.61±2.54 | **65** | 128.49±2.18 | **98** | 120.63±1.92 |
| **33** | 170.65±2.49 | **66** | 102.38±1.70 | **99** | 143.62±2.05 |
| **Min** | **66.53±1.39** | | | | |
| **Max** | **225.32±2.84** | | | | |
| **Mean** | **142±2.16** | | | | |


Fig. 2 Samples locations in area of study

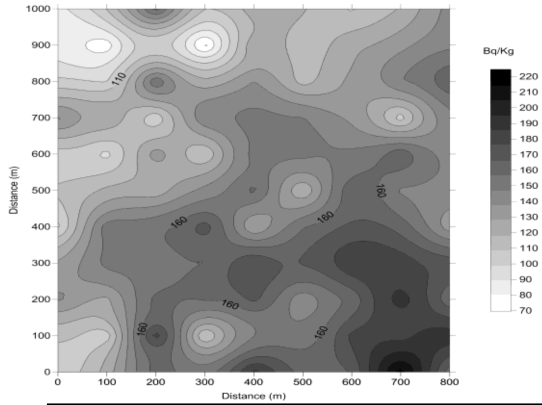


Fig .3 The Activity Concentrations for $^{40}$K in Study Region

Table. 3 Activity Concentration of $^{40}$K for Previous Studies

| **Country** | | **Activity Concentration (Bq.Kg$^{-1}$)** | |
|---|---|---|---|
| | | **$^{40}$K** | **Ref.** |
| **Egypt** | **Range** | **71.8±24-543.2 ± 26.5** | **[3]** |
| | **Average** | **264.1±11.94** | |
| **Jordan** | **Range** | **94±18.9-762±47.4** | **[4]** |
| **Qatar** | **Range** | **160±63-296±116.5** | **[9]** |
| **Saudi Arabia** | **Range** | **129±5.7-230±1l Bq** | **[10]** |
| | **Average** | **162.8±7.6** | |
| **Nigeria** | **Range** | **241.21-772.19** | **[11]** |
| | **Average** | **473.9S±165.27** | |
| **Egypt** | **Range** | **17.05-99.15** | **[12]** |
| **India** | **Average** | **274.6±86.** | **[13]** |
| **Turkey** | **Range** | **100–864** | **[14]** |
| | **Average** | **464** | |
| **World** | **Average** | **400** | **[15]** |
| **Iraq (Najaf)** | **Range** | **66.53±1.39-225.32±2.84** | **Madhloom ragion** |
| | **Average** | **142±2.16** | |

## 4. Discussion

Measurement of natural radioactivity in soil is very important to determine the amount of change in natural background with time as a result of any radioactive release. Monitoring of any release of radioactivity to the environment is important for environmental protection. The important radiological concentration consequence of natural radioactivity in soil is the effects of $\gamma$- rays on the human body.The levels of natural radioactivity in different soil samples collected from Madhloom region in Al-Najaf Al-Ashraf city were determined using NaI(Tl) detector. All the obtained $^{40}$K values show levels within the natural background values.

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