وزارة التعليم العالي والبحث العلمي
جامعة بابل / كلية العلوم
قسم الفيزياء

تقييم التأثير الإشعاعي للنويدات المشعة في عينات التربة والحبوب (الرز والقمح) التي تم جمعها من الشامية ، القادسية

أطروحة

مقدمة إلى مجلس كلية العلوم في جامعة بابل

كجزء من متطلبات نيل درجة دكتوراه فلسفة في العلوم / فيزياء

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بإشراف

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١٤٤٣هـ ٢٠٢١م

بسم الله الرحمن الرحيم

وَقُلْ رَبِّ زِدْنِي عِلْمًا

صدق الله العلي العظيم

من سورة طه الآية ١١٤

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Amer

Dedications

To
My Parents for ever lovely encouragement….

My wife , daughters and my sons….
.
My brother And my sisters for their help and support

Amer

Supervisor's Certification

We certify that this thesis titled **(Radiological Impact Assessment of Radionuclide in Soil and Grain (Rice and Wheat) Samples Collected From Al-Shamiyah, Qadisiyah)** was prepared by **(Amer Yassir Kadhim Hussein)** under our supervision at Department of Physics, College of Science, University of Babylon as a partial fulfillment of the of the requirements for the degree of Doctorate of philosophy in physics.

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الخلاصة

الهدف من هذا البحث هو كشف وقياس كمية الإشعاع الطبيعي للحبوب (الرز وقمح) المختارة ذات الاهمية الكبيرة على صحة الإنسان. كما تم قياس مستويات النشاط الإشعاعي الطبيعي في عينات التربة الزراعية. تم أخذ العينات من قضاء الشامية بمحافظة القادسية. والتي تعتبر المصدر الرئيسي للحبوب وخاصة الأرز والقمح في العراق. في هذه الدراسة استخدمنا كاشف يوديد الصوديوم المنشط بالثاليوم لقياس النشاط الاشعاعي الطبيعي لنظائر اليورانيوم-٢٣٨ والثوريوم-٢٣٢ والبوتاسيوم-٤٠. كما تم استخدام كاشف الاثر النووي في الحالة الصلبة لقياس تركيز اليورانيوم وغاز الرادون.

معدل فعالية اليورانيوم والثوريوم والبوتاسيوم في التربة والرز والقمح وجد (7.774±0.465, 2.301±0.217, 270.985±3.322, 1.383±0.179, 0.361±0.086, 21.136±0.838, 3.651±0.319, 0.752±0.126, and 50.882±1.382) $Bq.kg^{-1}$ على التوالي.

ووجد أن الترتيب في العينات على النحو التالي الرز < القمح < التربة.

كما تم حساب عامل الانتقال للنوى المشعة من التربة الى الحبوب (الرز والقمح) وهو النسبة بين تركيز النوى المشعة في الحبوب الى تركيزها في التربة.

باستخدام كاشف الأثر النووي ومصدر التشعيع بالنيوترونات تم حساب تركيز اليورانيوم في عينات التربة والحبوب (الرز والقمح). ومنها تم إيجاد انها تتبع الترتيب التالي الرز< القمح < التربة.

كما تم الكشف عن مستويات تركيز الرادون في عينات التربة الزراعية والحبوب (الرز والقمح) التي تم جمعها من مدينة الشامية.

الفعالية الاشعاعية لليورانيوم والثوريوم والبوتاسيوم وتركيز الرادون واليورانيوم في كل النماذج يتغير حسب نوع النموذج وموقعه. كما تم حساب مكافئ الراديوم والجرعة المكافئة والجرعة السنوية وجرعة الابتلاع اعتمادا على فعالية اليورانيوم والثوريوم والبوتاسيوم وكذلك معامل الخطورة الداخلي والخارجي . حيث كانت القيم ضمن المدى المحدد من منظمة الطاقة العالمية لمكافئ الراديوم وهو (٣٧٠) ولمعاملي الخطورة الداخلي والخارجي اقل من الواحد وكذلك محصورة بين ٢٠٠و٤٠٠ ملي سيفرت لجرعة الابتلاع كما محدد من المنظمات الدولية.

وبالنسبة لتركيز اليورانيوم والرادون فكان على التوالي ١١,٧ جزء بالمليون و٢٠٠ بيكرل لكل كغم. وأخيرا فان معامل الانتقال من التربة الى الحبوب اخذ الترتيب التالي الثوريوم < اليورانيوم < البوتاسيوم.

ومن ذلك يمكن القول أن كل العينات امنة وصالحة من الناحية الاشعاعية.

Mministry of Higher Education and Scientific Research
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Radiological Impact Assessment of Radionuclide in Soil and Grain (Rice and Wheat) Samples Collected From Al-Shamiyah, Qadisiyah

A Thesis
Submitted to the Council of College of Science, University of Babylon in Partial Fulfillment of the Requirements for the Degree of Doctorate of Philosophy in Science / Physics

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144٣ H.D. **202١ A.D.**

Summary

The aim of this research is detecting and measuring the nature radiation quantity for selected grain (rice and wheat) that are very importance for the protection of human health. Furthermore, the natural radioactivity levels in agricultural soil samples were measured. All samples were taken from AlShamiyah, governorate of Al-Qadisiyah, which is the main source of grain –specially rice and wheat- in Iraq. In this study we used the detection of NaI(Tl) to measure specific activity of ^{238}U, ^{232}Th and ^{40}K isotopes. CR-39 was used to measure the U and ^{222}Rn concentration.

The average of ^{238}U, ^{232}Th and ^{40}K in soil, rice and wheat were found (7.774±0.465, 2.301±0.217, 270.985±3.322, 1.383±0.179, 0.361±0.086, 21.136±0.838, 3.651±0.319, 0.752±0.126, and 50.882±1.382) $Bq.kg^{-1}$ respectively. The samples were discovered to be in the following order: soil > wheat > rice.

The transfer factor determines how many radionuclides are absorbed by grain (rice and wheat) from the soil (TF). It is known as the proportion between the concentrations of radionuclide in grain to concentrations of radionuclide in soil.

By using CR-39 detector and source of neutrons , uranium concentration were determined in samples of soil and grain (rice and wheat). The findings show that the uranium concentrations in the study samples varied substantially depending on the type of uranium material. The samples were discovered to be in the following order: soil > wheat > rice.

Radon levels were detected in farming soil and grain (rice and wheat) samples from Al- Shamiyah, a town noted for its agricultural grains, particularly rice and wheat.

The specific activity ^{238}U, ^{232}Th and ^{40}K and radon-222 found in all samples were analyzed whereby the results varied based on the type of samples and the location. R_{eq}, DR, AEDE, and E_{ING} are calculating by using the measured activity of ^{238}U, ^{232}Th and ^{40}K. To assess the health risk, both internal and external parameters of indices were calculated in all samples. Both grain and agricultural soil samples have activities of radium equivalent that are under the Organization for Economic Cooperation and Development (OECD) safety limit (370 Bq/kg). H_{in} and H_{ex} in grain, as well as DR, were all found to be below United Nations Scientific Committee on the Effect of Atomic Radiation (UNSCEAR) safety limit. H_{in} and H_{ex} possessed properties that were incompatible with one another. The ingestion dose for the year of the natural radionuclides from grain was discovered to be within the World Health Organization (WHO)-recommended range(250 - 400 μSv). Uranium and radon concentration found in agricultural soil and grain (rice and wheat) samples were within the safety limit reported by Environmental Protection Agency (EPA) which recommended maximum contaminant level of 11.7ppm and 200 Bq/kg respectively. Finally, transfer factors of ^{238}U, ^{232}Th and ^{40}K and U from the soil to grain were found in this order: $^{40}K > ^{238}U > ^{232}Th$.

All radioactivity candy is within the safety levels.

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List of Abbreviations

Abbreviation	Description
AEDE	Annual Outdoor Effective Equivalent
Am-Br	Americium-Beryllium Source
CR-39	Columbia Resin-39
DR	Dose Rate
FAO	Food and Agriculture Organization
GPS	Global Positioning System
IAEA	International Atomic Energy Agency
NaI(Tl)	Scintillation Detector
NCRP	National Council on Radiation Protection
NORM	Naturally Occurring Radioactive Material
OCED	Organization of Economic Cooperation and Development
PVC	Poly Vinyl Chloride
R_{eq}	Radium equivalent
SSNTD	Solid state nuclear track detector
TF	Transfer factor
UNSCEAR	United national scientific committee on the effects of atomic radiation

List of Symbols

Symbols	Description
ε	Absolute Efficiency
A	Activity
α	Alpha Particles
Bq	Becquerel
^{214}Bi	Bismuth-214
K	Calibration Factor
C_K	Concentration of Potassium
C_{Rn}	Concentration of Radon
C_{Th}	Concentration of Thorium
C_U	Concentration of Uranium
^{60}Co	Cobalt-60
Ci	Curie
H_{ex}	External Index
T	Exposure Time
I_γ	Gamma Emission Probability
Gy	Gray
E_{ING}	Ingestion dose
FDC_{ING}	Ingestion dose Coefficient
H_{in}	Internal Index

Symbols	Description
LT	Life Time
m	Mass of Sample
N_H	Number of Hours
ppm	part per million
$R_{eq.}$	Radium equivalent
R	Rontgen
Sv	Sievert
ρ	Track Density
γ	Gamma Ray

Chapter One

General Introduction

1.1 Introduction

People are affected by natural radiation in several various forms depending on elements of the present radioactive natural in any location; as, researchers investigated the natural environmental radiation and radionuclides checks are being conducted by background on the soil to detect ambient radioactivity[1]. Stages of radioactivity could use for evaluating general average of portion, tainting of radiation and various anticipate in ecological radiation brought about by atomic mishaps agricultural activities, transmission of radiation from soil to agricultural, crops and other persons more active [2].

The isotopes ^{238}U, ^{232}Th and K and decay of them give very important nature elements that contribute to a max part of radioactivity dose received by people; therefore, approached sixty radiation with a wide distribution have been discovered classification. radiation are encountered in earth Layers (rocks and soil) or bodies of water -ocean, sea and lakes . It accumulated easily into the chain of food [3].

The limited environmental layers on the ground radioactivity were related with composition of every geologic lithological in soils, the region and content of uranium, thorium, and potassium were separated. Soils are Classified to several kind depended from the chemical and physical Specifications. Many investigations undertaken around the world have revealed ^{232}U, as well as its decay products in rocks and soils, and ^{232}Th

in monazite soil, are the principal sources of large nature background radiation. [4].

People are exposed to nature radiation at varied amounts depending on nature radioactive minerals prevalent in each location throughout the world, nature environmental radioactivity and radiation in soil have piqued researchers attention. A principal source of radiation contamination is direct drops from the atom on plants. Finished products of fission are a strong maintained and absorbed and by particles of soil, similar to nature radioactive, which were widely dispersed at various depths of soil. As a result, understanding the distribution of radionuclides in soils is critical for reducing health hazards to the impacted population.

The present work, radiation dose and radioactivity concentration of soil and grain (rice and wheat) farms and virgin soils in Al-Shamiyah city, Al-Diwaniyah governorate in Iraq were measured. It is called it the "Wonderland" because of its fertility and abundance of water, and for the natural drainage that prevents the accumulation of salt in it due to the relative height of its land level. This city mainly depends on agriculture, as agriculture is the main engine of its economy, and one of the most important crops produced by the city is amber rice or Levantine amber, known to Iraqis for its delicious flavor and fragrant aroma in addition to the cultivation of wheat and palm trees[5].

We can define transfer factor (TF) is stable state a comparison of two physical access's concentration ratios. In this situation, a point is the ratio of an element's concentration in dried plants to its concentration in dried soil [6]. Transfer factor is based on plants kind, soil properties and the radionuclides type.

The ample amount of food to accommodate the increase in population the world. Finally, this has promoted a lot of rising the number of countries using of Mineral fertilizers in grain. Natural elements in soils have been reduced as a result of agricultural practices. Phosphate fertilizers are used to combat this depletion and enrich the soils as a result. Normal radioactivity nuclides such as uranium and thorium, as well as potassium, can be present in fertilizers. Depending on the field, the amount of radionuclides in fertilizers varies depending on the roots of the components [7].

1.2 Motivation and Problem Statement

People being are encouraged to consume very much grain (rice and wheat) in every day because this grain are rich in minerals, fibers and protein. They are containing essential and toxic metals and radionuclides proven benefits to the general health of people[8]. Iraq is one of the West Asian countries that has seen rapid development and widespread change, particularly in the economic sector. Agriculture has traditionally been the mainstay of the economy in this region. Grain (rice and wheat) represented the main crop in this region .

The grain contains protein, pectin, lipid, salt, and mineral in addition to being abundant in nutrient, fibers of dietary, and carbohydrates [9,10]. A number of studies have determined the radiation content in soil and the factor of transfer for radioactive nuclides from soil to grain (wheat and rice) [11-13]. As a result, the goal of this study is to study and analyze the level of radioactivity in soil and grains in farmlands in Al-Shamiyah city, Qadisiyah Governorate, Iraq.

In order to obtain baseline data from nature radiation levels, determine nature radiation at environmental isotopes haven carry out in several nations. [14-16]. When compared to future measurements, The data collection is used to determine any variations in the nuclear radiation background level that take place in the near future as a result of the numerous activities involved in radiation elements fallout. The measured values also contribute to the development of guidelines that could be used as future guidelines and for the administration of such components.

1.3 Review of Related Literature

There are many review of literature in this field. We put in two part as fallowing:

1.3.1 NaI(Tl) Detector

Rani A. and Singh S. in 2005 [17] measured the radioactivity for soil samples collected from Himachal Pradesh-India, they use photon of gamma spectrometer. For ^{226}Ra, ^{232}Th and ^{40}K, results of individual concentration radionuclides were 42.10 to 79.59 $Bq.kg^{-1}$, (51.93-105.92) $Bq.kg^{-1}$ and (96.22-161.37 $Bq.kg^{-1}$ respectively , rate was (58.27, 82.220 and 135.75) $Bq.kg^{-1}$. Concentrations of these radionuclides in soil were used to measure external exposure dose values. The absorbed dose rate has been calculated to be around 83.28 $nGy.h^{-1}$.

Erees F. S. and Sermin Ç K in 2006 [18] studied 64 sites in central Manisa were investigated for natural radionuclides in surface soils (Turkey). NaI(Tl) detector is using for measuring it .An activity of concentration was the highest for U, Th and K found at samples of sand were 155.948 $Bq.kg^{-1}$, 14.248 $Bq.kg^{-1}$ and 171,147 $Bq.kg^{-1}$ respectively. maximum value of equivalent activity of radium Ra_{eq} is 94.5$Bq.kg^{-1}$

determined from levels in sand, gravel and stone samples gamma-absorbed dose concentration. of terrestrial radionuclides. The air and their natural gamma radioactivity in soil samples were measured and found to be within the permissible limit.

Scheibel *et. al.* in 2006 [19] studied nature radioactivity in grain in southern Brazil and concentrations of radioactive material for ^{40}K, ^{232}Th, and ^{226}Ra. They were identified for profit samples of grain flour (soybeans, wheat, oats and maize) for security verification radiation of these nutrients by gamma rays detector. Levels of radioactive concentration of ^{40}K at soybean were 47.4 ± 3.0 $Bq.kg^{-1}$ and in maize 30.0 ± 0.30 Bq/kg and oats (1 ± 0.76) $Bq.kg^{-1}$and wheat 36.20 ± 0.40 $Bq.kg^{-1}$. For Cs, radioactivity levels in soybean meal samples were 0.07$Bq.kg^{-1}$, maize 0.01$Bq.kg^{-1}$, oats 0.03 $Bq.kg^{-1}$ wheat 0.02 $Bq.kg^{-1}$, and the highest levels were concentrations for ^{232}Th and ^{226}Ra are (0.70 ± 0.040 and 0.460 ± 0.030) $Bq.kg^{-1}$ respectively in soy flour.

El-Aydarous A**. in 2007 [20]** calculated concentration of activity for nature occurring radioactive nuclides radium, thorium and potassium at samples of soil on El-Taif, in Saudi Arabia. The activity of soil ranges about (13± 1.2 and 33± 3.4) $Bq.kg^{-1}$ for ^{226}Ra (11± 1 and 27± 4.2) $Bq.kg^{-1}$ for ^{232}Th and (129 ± 5.70 and 230 ±11) $Bq.kg^{-1}$ for potassium with rate was 23.8± 2.4 $Bq.kg^{-1}$, 18.6±1.7 $Bq.kg^{-1}$ and 162.8± 7.6 $Bq.kg^{-1}$ respectively. All samples have activities of radium equivalent smaller from limit value in the Energy Organization Company (OEC) is 370 $Bq.kg^{-1}$ the overall average outdoor terrestrial gamma dose rate is 28.98 $nGy.h^{-1}$and the corresponding outdoor is 0.04 $mSv.y^{-1}$.

Vaupotic J. ***et al.*** **in 2007 [21]** studied radioactivity in soil samples in the Slovenian and Croatian karstic region (Rossi) using the gamma spectrometer. The results of their study were(320–510) Bq.kg^{-1} to ^{40}K (50 - 85)Bq.kg^{-1} to ^{226}Ra, (52–75) Bq.kg^{-1} for ^{226}Ra and (52 and70)Bq.kg^{-1} for ^{238}U. The determination groups were discovered to be located outside of the impact zone of the nearby coal-fired power plant.

Lu X. and Zhang X. in 2008 [22] measured specific activities for ^{226}Ra, ^{232}Th and ^{40}K in soils for cuihiuoa Nation Geographic Park of the Mountains (China).By using detector of NaI(Tl). The main concentration of ^{226}Ra, ^{232}Th and ^{40}K was 27.2 ± 6.5, 43.9 Bq.kg^{-1}, 6.2 Bq.kg and 653.10 ± 127.60 Bq.kg respectively. Activity concentrations to the radioactivity nuclides are compared with the typical of values in the world and the means of activities in soil at China. Results were less than the permissible global limits.

AlaamerA. S. in 2008 [23] determined cons. activity for thorium, potassium and radium at soil taken from Riyadh, By using a NaI (Tl) detector in soil Saudi Arabia. The calculated specific activity of those radioactivity nuclides was compared to the forms reported around world. Average calculated specific activity for ^{226}Ra, ^{232}Th and ^{40}K were (14.50 ± 3.90, 11.20 ± 3.90 and 225.0 ±6.3) Bq.kg^{-1} respectively.

Al-Hamarneh I. F. and Awedallah M. I. in 2009 [24] used a NaI(Tl) detector, researchers investigated nature radioactivity concentration in surface samples of soil and assessed radioactivity hazard in the highlands of northern Jordan. Inclined ^{226}Ra, ^{232}Th and ^{40}K were (42.5, 49.91 and 291.11) Bq.kg^{-1} respectively .The total average absorbed dose rate in the research areas is 50.5 $nGy.h^{-1}$, while annual effective **dose equivalent** is 51.5 $nGy.h^{-1}$.

Senthilkumar B. et. al. in 2010 [25] measured levels of gamma rays of radiation in soil samples from Thanjavur (India) by using detector of NaI(Tl). Concentration of activity for ^{235}U, ^{232}Th and ^{40}K were (43.0 ± 9.04, 14.70 ±1.70 and 149.50 ± 3.10) $Bq.kg^{-1}$ respectively. Absorbed dose rate in air outdoors were determined was between (31.9 – 59) $nGy.h^{-1}$ and average 43.30 ± 9 $nGy.h^{-1}$. The world-averaged population measured value of 60 $nGy.h^{-1}$ was max. from these figures. An effective dose ranged from 39.2 to 72.6 $Sv.y^{-1}$, with a rate of 53.111 $Sv.y^{-1}$.

Saeed M. A. et al in 2012 [26] measured concentration and transfer factors by using high pure germanium detector (HPGe) for soil to grain samples are taken in two locations from Kadah. First at countryside region, larger values for factors of transfer to ^{238}U, ^{232}Th and ^{40}K in soil were 0.20, 0.15 and 1.43 respectively, the second was the city region. A larger values for factor of transfer for ^{238}U, ^{232}Th and ^{40}K are 0.09, 0.11 and 4.12, respectively .

Saleh M. A. in 2013[27] measured the radioactivity of ^{238}U, ^{232}Th, and ^{40}K in samples of soil obtained from Macadam Peninsula in Oman by use a high-resolution of gamma photons detector instrument. The mean levels of radiation in soil for ^{238}U, ^{232}Th, ^{40}K were 14.42 $Bq.kg^{-1}$ and cisium-137 9.96 $Bq.kg^{-1}$, 159.21 $Bq.kg^{-1}$ and 27.70 $Bq.kg^{-1}$ respectively. It was calculated that radium equivalent was 40.840 $Bq.kg^{-1}$.

Ali J. M. in 2013[28] studied nature radioactive at sample of soil Al-Najaf governorate in Iraq, by NaI(TI) detector. The results showed that concentration for ^{232}Th changed about 3.03 ±0.73 $Bq.kg^{-1}$ and

14.29±0.76 **Bq.kg-1** for ^{238}U from 19.28 ± 3.91 Bq.kg^{-1}to 1118.16 ±23.13 Bq.kg^{-1}and ^{40}K were varied from 184.04±9.23 Bq.kg^{-1} to 655.250 ± 34.99 Bq.kg^{-1}. The absorbed dose rate annual effective dose value (indoor and outdoor), hazard indices (internal and external) were to change from (22.26 Bq.kg^{-1} ,545.33, 0.11 Bq.kg^{-1} to 2.68, 0.03 Bq.kg^{-1} to 0.67, 0.13 to 3.17) and (0.18 to 6.19) with an average value of (59.26, 0.29, 0.07, 0.34) and(0.54) respectively.

Yousuf R. M. and Abdullah K. O. in 2013 [29] studied natural radioactivity in samples of samples were taken from several depths above the earth's surface, which is (0.1- 0.5) meters in some city on the east governorate of the Suleiman in Kurdistan of Iraq. By using a NaI (Tl) detector. The average value in concentrations of natural radionuclides ^{238}U 83.337 Bq.kg^{-1} , for ^{232}Th 19.147 Bq.kg^{-1} and for ^{40}K 284. 86 Bq.kg^{-1}. The findings revealed that the average concentration were larger than the actual global values.

Ademola A. K. *et al.* in 2014 [30] measured the specific activity for nature radioactive nuclides ^{238}U, ^{232}Th and ^{40}K at samples of soil at gold extracting area in Itagunmodi (Nigeria) by using NaI(Tl) detector. These natural radionuclides were subjected to radiological hazard assessments. Values of activity concentration are rated at different rates. The values for ^{238}U, ^{232}Th, and ^{40}K calculated in mining operations were (55.30 ± 1.20, 26.40 ± 2.70 and 505.10 ± 7.10) Bq.kg^{-1}, respectively.

Al-Gazaly H. H. *et al.* in 2014 [31] studied of the nature radiation at samples of soil in Iraq, Al-Najaf Province by the detector of NaI(Tl). The findings revealed that the particular activity for ^{238}U 77.33±5.8535 Bq.kg^{-1}, ^{232}Th 9.36 ± 0.9735 Bq.kg^{-1} and ^{40}K 426.31 ± 21.35 Bq.kg^{-1} .

When the measured values were compared to the corresponding worldwide average values, it was discovered that the most specific activity of ^{238}U and ^{40}K radionuclides in the studied samples was greater than the global mean activity.

Alsaffar M. S. *et al.* in 2015 [32] determined the distribution of radioactivity and factors transfer for plants are important parameters used for evaluating radionuclides contamination in environment and its dangerous to people. From that study activities of ^{226}Ra, ^{232}Th and ^{40}K were determined via gamma ray spectrometer for samples of components of rice (root, straw, husk, and grain) as well as soil took extracted from crops fields in Penang from Malaysia. They were also studied for their predictions the transfer factor from soil to grain .

Isinkaye M. O. and Emelue H. U. in 2015 [33] evaluated the specific activity concentration of the natural radioactivity nuclides and their risk indexes in the samples collected from the soil of Oguta Lake/ Nigeria uses NaI (Tl) detector, mean value of the specific activity 47.89 $Bq.kg^{-1}$, 55.37 $Bq.kg^{-1}$ and 1023 $Bq.kg^{-1}$ for all ^{226}Ra ,^{232}Th and ^{40}K respectively. They found that the absorbed does is higher than the global allowable does due to environmental pollution due to oil exploration. **Almayahi B. in 2015 [34]** used a NaI (Tl) detector to evaluate nature radiation isotopes. that machine was used for determining the quantity and quality levels the ^{238}U and ^{232}Th in samples of soil taken from Al-Najaf. Mean concentration are about (102 - 448) $Bq.kg^{-1}$ and (79 - 1887) $Bq.kg^{-1}$ in ^{238}U and ^{232}Th respectively.

Hatif K. H. and Muttaleb M. K. in 2015 [35] studied the measured level of radioactivity in ten soil sites in the city of Hilla (Iraq) by using

NaI(Tl) detector, the average specific of radioactivity of ^{328}U, ^{232}Th and ^{40}K were (14.079 ± 0.46, 12.326 ± 0.43 and 416.655±2.86 Bq. Kg^{-1} respectively.

Usif M. and Al-Taher A. in 2016 [36] studied radiation activity from nature activity ^{226}Ra, ^{232}Th and ^{40}K in soil of Red Sea/Egypt sediments by using a sodium iodide containing thallium. The results obtained were as follows: specific activity 22.2 ± 1.7 Bq.kg^{-1} 19.2±2.5 Bq.kg^{-1} and 477.6 ± 27.6 Bq.kg^{-1} to ^{226}Ra, ^{232}Th and ^{40}K respectively.

Karim M. S. *et al.* in 2016 [37] used NaI(Tl) scintillation detector of crystal dimensions (3"×3"), an active site of radioactive elements was calculated for 10 samples of soil taken from the antiquity's region of archaeology Al-Hilla city. Values of concentrations to ^{238}Uabout (9.050 Bq.kg^{-1}) and (21.221 Bq.kg^{-1}), its mean is(15.485 Bq.kg^{-1}), concentrations to ^{232}Th about (11.159 Bq.kg^{-1}) and (19.400 Bq.kg^{-1}) and mean is (15.5005 Bq.kg^{-1}), while a concentration activity for ^{40}K about (122.255 Bq.kg^{-1}) to (232.550 Bq.kg^{-1}), and average was (170.200 Bq/kg).

Kadhim I. H. and Muttaleb M. K. in 2016 [38] measured the amount of natural radiation of the Tuirij region in the province of Karbala (Iraq). The technique of gamma ray spectrometry was applied using NaI(Tl) gamma ray detector and activity cons. levels due to ^{40}K, ^{238}U and ^{232}Th were measured in. Activity cons. of the concern radioactive nuclides for the soils were as follows ^{40}K was (271.2±170 Bq.kg^{-1}) with the mean (245.1 Bq.kg^{-1}) ^{238}U was (30.96±5.86 Bq.kg^{-1}) with the mean (19.45 Bq.kg^{-1}) Bq/kg and ^{232}Th was(67.09±2.9 Bq.kg^{-1}) with an average (24.47 Bq.kg^{-1}) Bq/kg respectively.

Rajesh S. et al. 2018 [39] studied the ionizing radiation emitted from the nuclei of ^{40}K, ^{232}Th and ^{238}U for soil samples from Devadurga and Lingasugur of Raichur area of Karnataka, India. Which were found in environmental materials and which it contributed significantly to the radiation dose received by humans, using NaI(Tl) detector(4” × 4”) the sample spectrum was measured for 60,000 s. They found in range (10 – 119) $Bq.kg^{-1}$, (8 – 285) $Bq.kg^{-1}$ and (46 – 1646) $Bq.kg^{-1}$ respectively.

Azeez H. H. et al. in 2019 [40] The concentration levels of highly radioactive activity nuclides at grain and soil collected in greenhouses and agricultural fields in Erbil. A high pure germanium detector (HPG) was used to measure the results. In Kurdistan of Iraqi, were calculated by researchers. For radioactive nuclides, soil-to-grain transfer factors were calculated. The specific concentration for ^{226}Ra, ^{232}Th, and ^{40}K at agricultural soils are (11.940 to18.240) $Bq.kg^{-1}$, (8.8 to 12.36) $Bq.kg^{-1}$and (247.650 to 338.260) $Bq.kg^{-1}$ respectively according to a findings. Activity of concentration for ^{226}Ra, ^{232}Th and ^{40}K in grain about (0.20 - 1.450), (0.110 - 0.480) and (68.07 - 1355.360) $Bq.kg^{-1}$ respectively. Transfer factor from soil to grain for ^{226}Ra, ^{232}Th and ^{40}K were between (0.011 and 0.087), (0.011 - 0.046) and (0.201 - 5.130) respectively.

Oluyide S.O *et al.* in 2019 [41] used a portable survey meter with a Global Positioning System (GPS) and a well-calibrated NaI(Tl) detector system, researchers assessed the natural radioactivity and radiological health effect of soil, food, and water in Fashina village, Ile-Ife, Osun State, Nigeria. In soil/food and water samples, the mean exposure rates in the study region were 0.14 $Sv.hr^{-1}$ and 0.12 $Sv.hr^{-1}$ respectively. In soil samples, the mean radioactivity content for ^{238}U, ^{232}Th, and ^{40}K was 12.14 4.17$Bq.kg^{-1}$, 23.23 7.67 $Bq.kg^{-1}$ and 270.14 61.79$Bq.kg^{-1}$ respectively; in water samples, the mean radioactivity content for ^{238}U, ^{232}Th and ^{40}K was 8.56 2.80 Bq.kg^{-1}, 13.17 4.48 Bq.kg^{-1} and 89.41 24.15 Bq.L^{-1} .The absorbed dose rate in soil, food, and water was found to be 30.91 nGy.h^{-1}, 15.64 nGy.h^{-1} and 12.47 nGy.h-1 respectively, while the annual effective doses were found to be 37.90 Sv.y^{-1}, 178.79 Sv.y^{-1}and 1085.23 Sv.y^{-1} (AED). In soil, food, and water, the radium equivalent (Ra_{eq}) was 66.16 Bq.kg^{-1}, 34.28 Bq.kg^{-1}, and 27.31Bq.L^{-1}, respectively. In soil, food, and water, the radium equivalent (Ra_{eq}) was 66.16 Bq.kg^{-1}, 34.28Bq.kg^{-1}, and 27.31Bq.L^{-1}, respectively. For soil, food, and water, the external and internal radiation hazard indices were 0.18 and 0.21, 0.09 and 0.12, 0.07 and 0.09 respectively. For the soil, food, and water samples, the excess Lifetime Cancer Risk (ELCR) in (x 10^{-3}) was also 0.13, 0.63, and 3.80, respectively.. It was discovered that the study area had higher values for certain exposure rates, radioactivity contents, and radiological effect parameters than the control area and the world average values, posing a significant health risk to the atmosphere and its inhabitants.

Ilemona C. et al. in 2020 [42] measured ^{238}U and ^{232}Th containing mineral grain (monazite and zircon) with monazite the most abundant radionuclides mineral particles. The cracked and pitted surface morphologies of these radionuclides particles (with sizes ranging from 10 - 80 µm) suggest that they are susceptible to dissolution into more toxic and easily inhalable PM2.5 aerosol particles, which could provide a concentrated dose and triggering chronic respiratory diseases. Activity rates and radioactivity damage indexes for coal ash samples from both mines were three to five times greater than the global level in soil, As a result, these hazardous waste products should be appropriately stored in wet ponds to avoid hazards from excessive indoor access to gamma radiation, radon gas, and inhalation of liberated radionuclides.

Leandro B. *et al.* in 2021[43] calculating committed effective dose and the risk of cancer as a result of ^{40}K, ^{226}Ra, and ^{232}Th intake from crops grow in H.B.R.A. For ^{40}K, ^{226}Ra, and ^{232}Th, larger activity cons. are (606.20 - 25.130), (8.07 6.37), (10.010 - 1.450) $Bq.kg^{-1}$respectively. The willing to commit effective dose was assumed to be 0.5 $mSv.y^{-1}$, and the risk of developing cancer suggests that unrestricted usage of beans grown in this H.B.R.A. is not beneficial.

1.3.2 CR-39 Detector

Ismail A. H. and Jaafar M. S. in 2010[44] measured the concentration of radon gas in 31 sites in Kurdistan measured and found the average radon gas concentration was143.77$Bq.m^{-3}$.

Al- Wasity A. M. in 2010[45] measured uranium concentrations in soil sample in Wasit Governorate, Iraq. Uranium concentrations ranged from 1.21 to 1.83 ppm with a mean value of 1.42 ppm .

Hassan A. H. et al. in 2011[46] determined the radon gas concentration ^{222}Rn in soil at 15 regions in Al-Najaf governorate. In each region several different depths were taken for soil gas determents. The results suggested that the maximum activity concentration was (92900 ± 40.0) $Bq.m^{-3}$ on depth was 60 cm in area of AlAmeer and smallest activity cons. were (9 ± 17) $Bq.m^{-3}$ on 5 cm depth in area of Al-Shoora. The study's findings revealed that the background of region radionuclides stages were within natures limits.

Al-Hamidawi A. A. et al. in 2012[47] measured radon and thoron concentration in Al-Kufa city soil in twenty regions for 3 - depths about (0.5- 1.5) meters The findings revealed as well as that rates for radon and thoron gas emission differed from one area to the next, depending on the rock structures.. Activity concentration of radon in soil was changed from (12775±400 $Bq.m^{-3}$) in 1.5 m under surface of earth in area 2 to (41.45±17 $Bq.m^{-3}$), for 1.5 m under surface of earth for (20s). Concentration of thoron for soil was varied between (198±8.5 $B.qm^{-3}$) at 1.5 m under surface of earth in areas 1 and 2. These concentration values were well below the allowed levels whose range was (0.440 $kBq.m^{-3}$).

Muthana A. S. and Omer H. S. in 2015[48] determined uranium concentration for soil samples in city of Fallujah by using of (CR-39) detector**.** The maximum value of uranium was (2.158 ppm).

Hatif K. H. and Muttaleb M. K. in 2016 [49] studied the concentration of radon and for ten sites of the soil of the city of Hilla (Iraq). In this investigation solid state nuclear detector were used, the samples were taken from the surface and the depth 30 cm for each location. Maximum activity of radon activity was (12700 $Bq.m^{-3}$) while the minimum radon activity was (25 $Bq.m^{-3}$).

Ajiboye Y. et al. in 2016 [50] determined the concentration of radon in the soil of Aramoko, Ekiti State, Nigeria, using CR-39. Gas concentration was found in the study area between (630 and 35040) $Bq.m^{-3}$ and mean value was 9820±0.56 $Bq.m^{-3}$. this results were higher than the allowable limit.

Nidhala H. K. et al. in 2016 [51] measurement the concentration of uranium in soil for several areas in south east of Baghdad using (CR-39). the maximum concentration of uranium at the Al-Twitha was (0.881±0.056 ppm) and minimum concentration Salman paak (0.441±0.026 ppm) .

Rejah B.K. and Ashoor G. T. in 2017 [52] studied the concentration of the radon gas was calculated in Al-Haswa city in Baghdad governorate using a technique Nuclear Impact Tracking Detector (CR-39). Eight samples were selected in eight districts of the city Al-Hasswa in Baghdad governorate and VIA set the dose measures for 30 days. The rate of concentration of the radon gas was (424.24 $Bq.m^{-3}$), which was less than the global permissible range (1100$Bq.m^{-3}$). Calculate the concentration of potential alpha energy and the annual effective dose. The relative relationship between the dose determined the annual equivalent and the concentration of the radon gas for a region under the study.

Murtatha Sh. A. et al in 2018 [53] determine the radon concentration and its distribution in agricultural soil in the Seberang Perai, Malaysia by using plastic track detectors (CR-39) to measure the exhalation radon rate in the virgin and fertilizers soils. the exhalation radon rate changes between (2.449 and 6.28) $mBq.kg^{-1}.h^{-1}$.

Al-Hamidawi A. A. in 2018 [54] estimated the number of αparticle by SSNTD technique and CN-85 in Iraq/Al-Najaf governorate set values. He measured the concentration of radon and thoron gas of the soil, and found that the higher value was 1194.69 $Bq.m^{-3}$ for ^{222}R and the lower value was 506.84 $Bq.m^{-3}$.

1.4 Aim of the Present Work

This study aims to evaluate NORM's stage for agricultural soil and grain (rice and wheat) at agricultural lands in Iraq's Qadisiyah governorate's Al-Shamiyah city. These goals could meet with completing the following sub-objectives:

1. Measured the specific activity for ^{238}U, ^{232}Th and ^{40}K isotopes and concentration of uranium and radon in soil and grain (rice and wheat) samples.

2. Determined transfer factor from soil to grain (rice and wheat) samples for ^{238}U, ^{232}Th and ^{40}K isotopes and uranium.

3. Calculated the activity equivalent of radium, dose rate, internal and external hazard indices, yearly outdoor effective dose equivalent and ingestion dose from eating grain are all examples of radiological risks for (rice and wheat).

Chapter Two
Theoretical Part

2.1Introduction

Radionuclides such as ^{238}U ,^{232}Th and ^{40}K are isotopes found in all common forms of rock and soil. Besides that, such radioactive elements disintegrate into other radioactive nuclides, producing a degradation system.. Radionuclides in the environment, both natures or manmade, can enter in bodies of peoples by inhalation and ingestion. As a result, it is critical to investigate these radioactive particles in each ecological subsystem (air, lithosphere., troposphere., and biosphere.) around the world, as well as to assess the risks to public health among the numerous studies on nature sources isotope. [55,56].

2.2 Sources of Natural Radioactivity

A small amounts of radionuclides is found in the global environment that surrounds us. Usually, radioactivity nuclides are divided to several types: rays of cosmic, sources of terrestrial and sources of artificial [57].

Cosmic rays arrive to earth as seen from space. They are sources of various radionuclides in the world, including ^{3}H, ^{7}Br, ^{14}C and that are lived very short in comparison with the earth' age[57].

Radionuclides' terrestrial are lived very long species which have been present on form the earth before about four billion years. They are divided to two types: first is the series of radionuclide which are beginning by radionuclides that are the parents of radionuclides that decay in a series of other nuclear radiation isotopes with varying halflives and modes of disintegration, eventually decaying to stable isotopes [56]. There were found tree different nature series to choose from: are began with ^{238}U, ^{235}U and ^{232}Th-232 as noted in Figures 2.1 to 2.3 respectively. Second is non-series Radioactive elements decay into stable nuclides in a direct process. The isotopes of uranium are the most significant radionuclides in this group. ^{40}K, ^{50}V, ^{87}Rb, ^{113}Cd and ^{115}In. The most significant radionuclide for the population dose is potassium. [58-60].

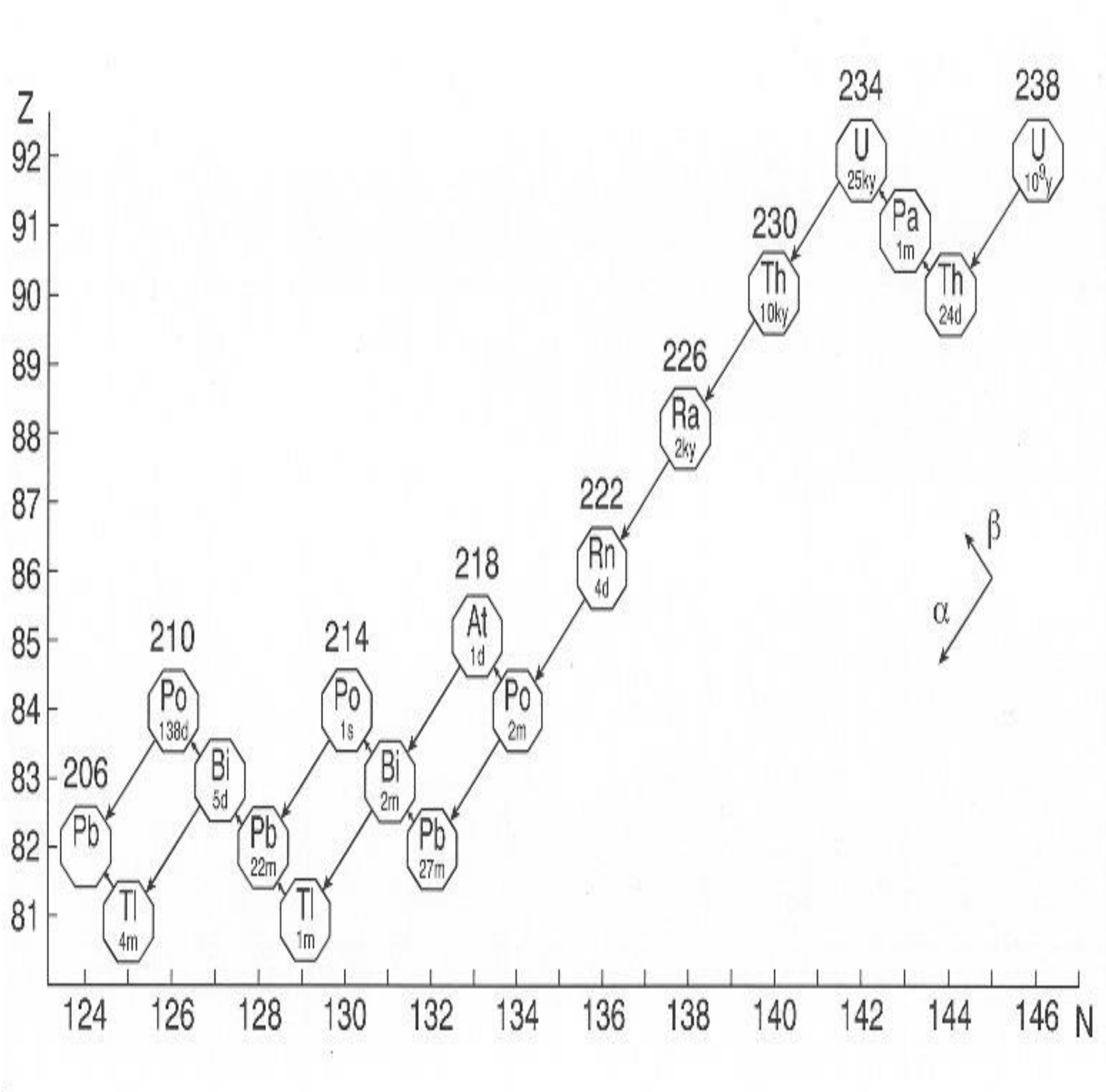

Figure 2.1 Sequence of ^{238}U decay[61].

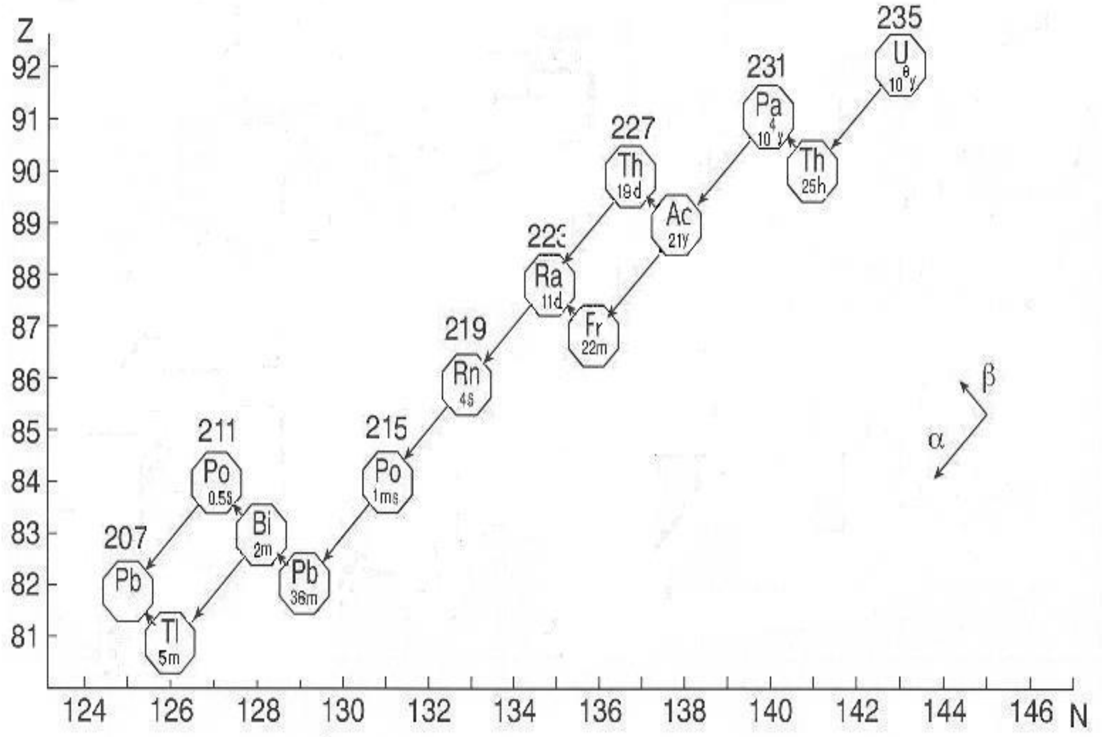

Figure 2.2 Sequence of ^{235}U decay[61].

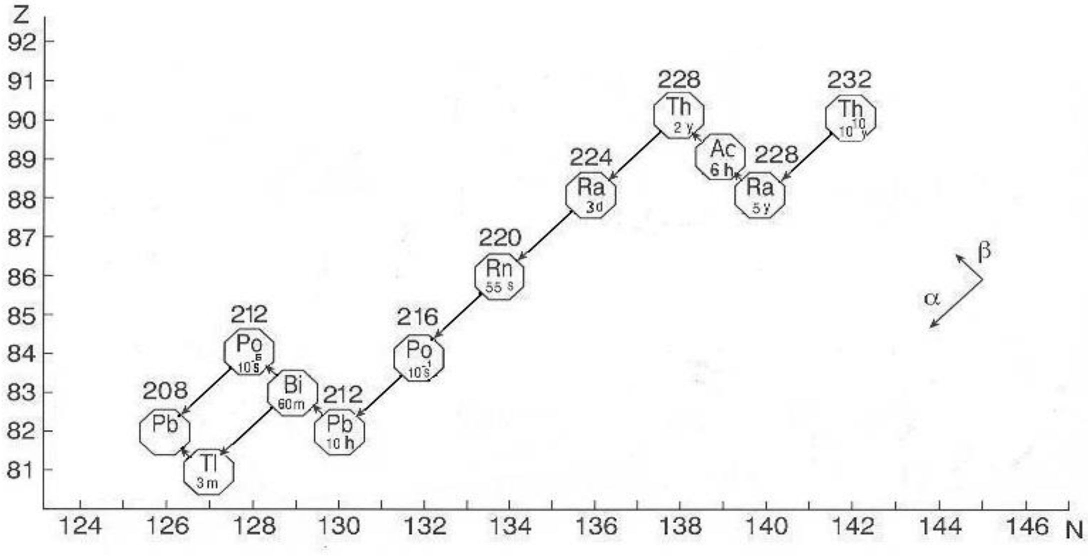

Figure 2.3 Sequence of ^{232}Th decay[61].

Artificial sources are created by human's efforts, which vary in location and time depending on global nuclear activities and other factors.. They know conventional nuclear power sources. standard nuclear sources, nuclear power plants, uranium milling and mining, oil discovery, and other industries. Furthermore, these sources are used in scientific, agriculture, and industrial applications. For research purposes, some standard nuclear sources are used. This work study the natural sources of radioactivity nuclides found in the environment, especially terrestrial radionuclides such as ^{238}U, ^{232}Th, their daughters and ^{40}K[62].

2.2.1 Potassium- 40

There are 22 nature isotopes non-series terrestrial radionuclides that are limited. ^{40}K is the most prominent among them from bio- environmental point of view. Half-life or it is very long -1.3 x 10^9 years- which deteriorates by beta particles the emission of calicium-40, The excited state of aragon-40 is then captured by K, and gamma rays are emitted to the aragon-40 ground state, as shown in Figure 2.4. ^{40}K is found in a naturally occurring potassium at a concentration of 0.01 percent. The concentration of ^{40}K in rocks varies from one to five percent with an average value of 2%. A man has mass seventy kilograms contains approximately .

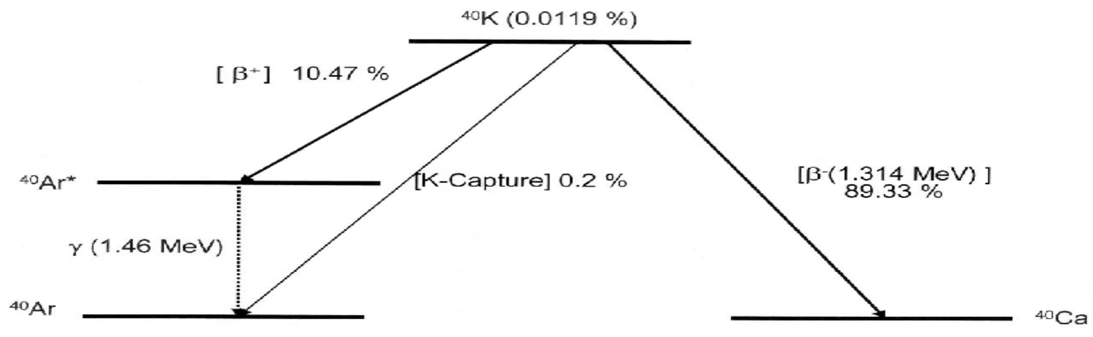

Figure 2.٤ Decay scheme of ^{40}K[63]

2.2.2 Uranium Series

The element uranium is made up of four isotopes with mass numbers of ^{230}U, ^{234}U, ^{235}U, and ^{238}U. ^{238}U has a 99.28% abundance and is generally in equilibrium with ^{234}U, which has a 0.0058 percent abundance. ^{235}U is the first element of the actinium sequence, and it makes up 0.71 percent of the total. ^{230}Uis a short half-life member ^{238}U sequence. The uranium sequence contains radionuclides of particular interest, such as ^{226}Rn and ^{222}Rn[64].

Internal emitters of Ra and its offspring are dependable for a significant majority of the dosage received by humans from natural sources. With half-age of 1622 y, ^{226}Rn emit α-particles. ^{222}Rn, byproduct of radium decay, is the source of radioactive contamination. [64].

2.2.3 Thorium Series

The thorium series, which is began by thorium, consists of twelve members. They emit alpha and beta particles with many gamma rays decays into ^{208}Pb. All daughters product are short-lived in comparison to ^{232}Th. The properties of the thorium series in many ways, the uranium series differs from the uranium series[64].

2.3 Radon

Radon is a noble gas that results from uranium decay. In nature, it can be found in abundance. Because of the alpha particles released by ^{226}Rn, radon can often be found in naturally high concentrations that are higher than the acceptable limit. It is found in almost very many kinds for soil even though cons. change wide [65]. These typically ascend from the ground to the air. ^{222}Rn dissolves with a half-age was 3.8 days, resulting in two brief daughters, notably, ^{218}Po, ^{214}Pb, ^{214}Bi and ^{214}Po. Some atoms enter in air or water from the soil. As a consequence, radon can be found both indoors and out. When radon progenies are inhaled, alpha particles are emitted from the lungs. The decaying results of radon are by far the most critical and well-controlled contributions to the inhalation dose. The key natural causes of irradiation in humans are the air, there is radon and its daughter.. As seen in Table 2.1. Indoor activity concentrations of radon are max., Nevertheless, also a significant amount outside. In addition to affecting the general population, Most cancer deaths among crypto mining are caused by radon.[2].

Table 2.1 Typical volume activities of radon isotopes and effective dose [66]

Nuclide	Parent	Half-life	Activity Outdoor ($Bq.m^{-3}$)	Activity Indoor ($Bq.m^{-3}$)	Effective dose outdoor ($\mu Sv. y^{-1}$)	Effective dose Indoor ($\mu Sv. y^{-1}$)
^{222}Rn	^{226}Ra	3.82d	10	10-100	100	1000
^{220}Rn	^{224}Ra	33.65s	10	2-20	≈10	≈90

Figure 2.5 shows that more than nature sources of person exposure include gas of radon, the person body, outer space, rocks, and soil. The remainder (16%) is derived from man-made radiation sources, primarily medical x-rays. Man-made radiation is more dangerous than natural radiation because it is more concentrated more spread out and less concentrated, and is therefore less harmful [66]. The most common source of nature rad. is Radon, a radioactive gas produced by the breakdown from radium in rocks and minerals as component of the uranium radioactive process.

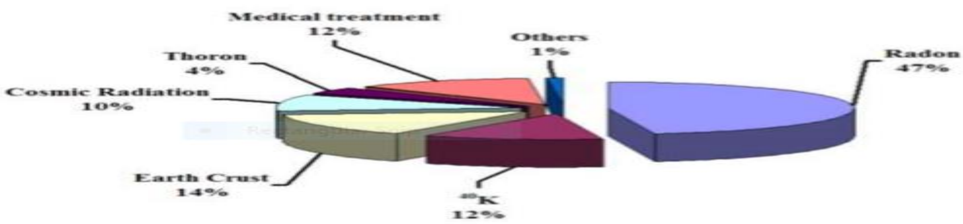

Figure 2.5 Sources and average distribution of natural radiation background of the world population [66].

2.3.1 Radon Decay

Thorium and uranium are both naturally occurring elements that are found in small cons. in rock and soil and are both sources of radon-222. Radon is produced by the radioactive decay of the element radium, which is itself a decay product of either uranium or thorium, so radium present in various materials such as soil, water, and building materials is a source of radon and its decay products in the environment [67].

Every square mile of soil to a depth of 6 inch. is estimated to contain about one gram of radium, which emits radon in trace amounts into the atmosphere.. There are four Rn short living daughters ^{218}Po, ^{214}Pb, ^{214}Bi and polonium-214. Two of the radon daughters are alpha emitters (^{218}Po and ^{214}Po) and the others are beta emitters (^{214}Po and ^{214}Bi) as shown in figure2.6.

Whenever ^{222}Rn dissolves, its progeny experience a sequence of modifications over the course of a few hours, including two alpha particles decays and two beta decays, eventually yielding remarkably constant ^{210}Pb [68]. Although this beta emitters produced by that kind of decay cycle have the potential to beta live cells, by ionization, it is the alpha particles generally 20 times more damaging than beta particles, that contribute, the most risk to exposed, regenerative cells. The main concern about indoor gas of radon was increased risk of cancer for lung causes by inhaling radon and its byproducts. It is worth remembering that radon produced in any material at a steady rate that is independent of any external factor [69]

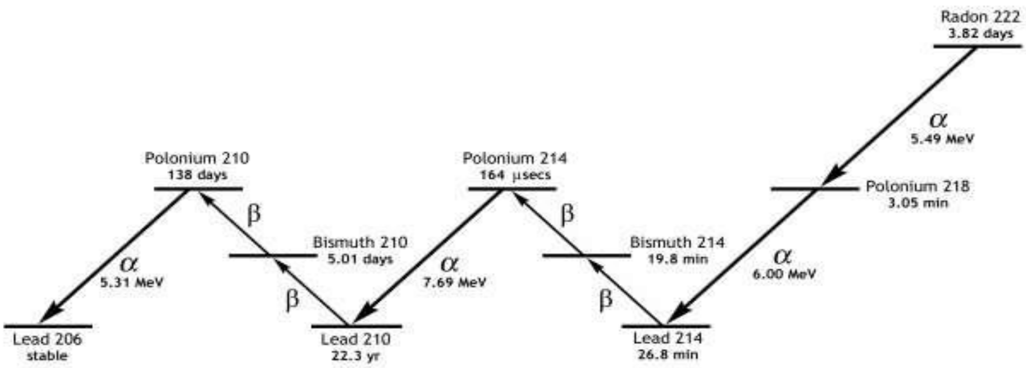

Figure 2.6 Radon decay chain[66]

2.3.1 Physical and Chemical Properties of Radon

Radon is a chemically inert noble gas with the slightest ability to form compounds under laboratory condition. It is found in almost all materials and, in the most part (90 %), is trapped in solids containing its precursor chemicals, ^{226}Ra. At ordinary temperature radon is a colorless gas as Table 2.2 When radon is cooled below the freezing point, it emits a brilliant phosphoresce that turns yellow as the temperature drops and orange-red at the temp. of liquid air. Some radon may diffuse into other media, such as the surrounding water or air, and the cons. of radon is frequently greater than the concentration of ^{226}Rn. [70].

Table 2.2 Some properties of radon[69]

Property	Value
Volume at 1 Bq of Rn-222 at NTP	$1.6*10^2 m^3$
Boiling point	-61.8°C
Melting point	-71°C
Vapor pressure at-144°C	0.13Pa
Density at NTP	$9.96 kg/m^3$

2.4 The Soil

People and their health depend on soil. It is a resource that can be used as a shelter as well as a source of food. Terrestrial radioactivity nuclides have been discovered at every stage of every area in the world, and they are dependent on the parent rocks that shape the soil. Natural radioactive materials account for the majority of radiation doses obtained by humans. [71]. A lot of studies in the world measured the natural radioactivity level , such as ^{238}U, ^{226}Ra, ^{232}Th, their decay products and ^{40}K in soil [2].

Table 2.3 Typical activity ranges concentration of ^{226}Ra, ^{232}Th and ^{40}Kin various kinds of Nordic rocks and soils[2]

Type of soil	^{226}Ra (Bq.kg^{-1})	^{232}Th (Bq.kg^{-1})	^{40}K(Bq.kg^{-1})
Gravel	10 - 90	2 - 80	300 - 1100
Sand	<4 - 60	2 - 80	150 - 1100
Eolian Sand Silt	5 - 20	10 - 20	400 - 10^3
Silt	5 - 70	5 - 70	500 - 10^3
Clay	15 - 130	10 - 100	600 - 1200
Till	100 - 170	15 - 100	500 - 1200
Till with alum shale	180 -2500	30 - 50	600 - 1200

A few of the sources of radiation other than those of nature original primarily due to the extensive use of fertilizers is survey shown that the application of agricultural.[72,73].

2.5 The Rice

Rice is the seed of a grassy Asian or African rice variety. As a grain of rice. A large part of the world's population, especially in Asia use rice as the most widely consumed staple food . It is the third most produced agricultural commodity in the world [74]. It is often grown as an ornamental crop, however it can thrive as a permanent under hot environments and yield cereal crops grain for up to 30 y.. Rice agriculture has been well to nations and locations with cheap labor prices and increased rain, as rice farming is labor - intensive and needs a lot of water Rice, on the other hand, can be cultivated where ever, including on a slope or hill with the use of water-controlling platform structures. Despite the fact that its primary plants are common in Asia and portions of Africa, centuries of trading and export have made it a part of many cultures all over the world. [75].

2.6 The Wheat

Wheat is a grain widely cultivated for its seed, grain which is a staple food in a worldwide [76]. Common wheat is the most widely farmed. Wheat is a significant carbohydrate source. It is the most common source of plant rich in protein diets, with a protein level of around 13%, which is reasonably high when compared to other main grains but low in nutritional value for giving important amino acid. Wheat is a source of several minerals and dietary fiber when consumed whole grain. Gluten – the main component of wheat protein – can cause colon cancer, no coeliac sensitivity and ataxia of gluten and herpetiform for dermatitis in a tiny percentage of a general population. [77,78]. Table 2.4 showed activity cons. for ^{226}Ra, ^{232}Th and ^{40}K in soil and grain (rice and wheat) [40].

2.7 Transfer Factor

The natural radioactivity is found in soil that comes mainly from the terrestrial radionuclides ^{238}U, ^{232}Th series and ^{40}K isotope which are composed at trace stage in the crust of Earth and distribution in ground formation [79,80]. Naturally, radio nuclides is found everywhere in the soil. It is transfer to plants through the consumption of radioactivity either through system of root or by external surfaces of plant [80].

Table 2.4 Activity concentrations for ^{226}Ra, ^{232}Th, and ^{40}K in soil and grain (rice and wheat) [40].

Sample	Activity concentration in plant crops (Bq/kg dry weight)		
	^{226}Ra	^{232}Th	^{40}K
soil	16.18± 0.61	10.75 ± 0.54	294.96 ± 15.38
rice	0.36 ± 0.09	0.11 ± 0.02	68.07± 4.91
Wheat	0.63 ± 0.19	0.25 ± 0.05	153.72 ± 11.78

The consumption of radioactivity from the soil by crops is calculated using a transfer factor (TF), that is defined as the ratio of radioactivity concentration in different plant types to radionuclides per unit mass in the soil-rooting region. The pathways of radionuclide transmission from soil to plants are depicted in Figure 2.7. The transfer factor was given by equation [8] :

$$TF = \frac{C_G}{C_s} \text{ ....2.1}$$

where:

C_G is the concentration of the radionuclide in type (G) Grain (Bq.k^{-1}) C_s is the concentration of the radionuclide in soil rooting zone (Bq /kg). The factor of transfer The values of radionuclides fluctuate a lot. The type of plant and type of soil are the mean factors of transfer that cause this variability for any given radionuclide. Other considerations include agricultural methods (especially fertilizer) and weather variations throughout the growing season, are on the other hand. [81].

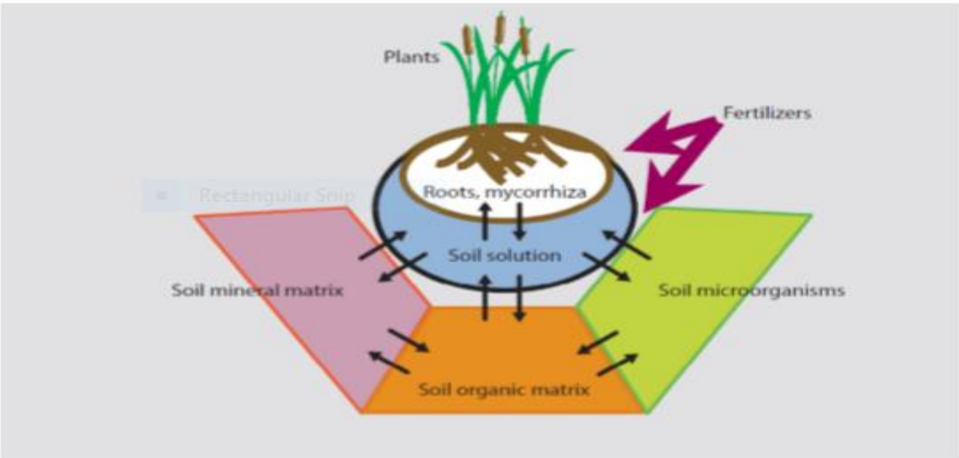

Figure 2.7 Pathways of radionuclide transfer from soil to plants [8]

Roots get their nutrients primarily from the solution of soil. Root uptake consumes the solutes in the solution of soil on a continuous basis However, it is also regenerated from the solid state of the soil. Because of the intricate, temporal, and geographical structure of the soil-plant relationship, estimating radionuclide uptake from soil is difficult. A lot of coefficient influence is a transfer factor, including ionic chemical composition and interactions. They're both portrayed of root uptake and adsorption on soil sorption complexes. The amount and quality of soil colloids influence the amount of ionic in water (clay minerals and organic matter). Concurrently, it varies throughout the planting period due to weather and agricultural practices (droppings and fertilization), as well as pH, which affects the bioavailability of many elements. [82].

The factor of transfer is typically used for assessing the impact in radioactivity nuclide releases into the atmosphere The understanding of radioactivity distributions in plants and vegetation and levels of concentration are of great importance because it offers vital info on radiation in the environment [83]. The transfer of radioactive nuclides from soil to grain (rice and wheat) via root uptake is crucial to investigate, especially given the buildup of these radionuclides in food chains. A main purpose of this type of study is to measure expositions to specific many members of the general public radiation releases. Furthermore, awareness of the presence and accumulation of radionuclides in plants is critical since consumers of these products could be at a higher risk of developing health problems such as cancer. [84].

2.8 Pathways of Radioactivity to Body of Human

Radioactivity nuclides come to the environment and can provide both external and internal. Result of the intake of radionuclide represent the internal doses. The main routes of radionuclides intake for the members of the public is ingestion and inhalation are:

2.8.1 Ingestion

as well as their daughters Ingestion involves ingesting radioactivity by drinking water and consuming food items. Radionuclides may stable in the body of some people extended period of time, whereas others die soon. [85].

٢,8.2 Inhalation

Inhalation refers to the ingestion of radioactivity from airborne dust particles that contain radioactive elements. Rn decay products are the most significant contributors to inhalation doses. When products decay of Rn and the Rn itself are inhaled, they build up on the lungs' lining. Furthermore, many cancer deaths within uranium miners are caused by radon due to the highest exposures linked with such risks. When radon daughters that have been inhaled die, alpha particles are discharged into the lungs. Lung cancer genetic material is the only type of cancer that has been proven to be connected to radon exposure and radon product degradation, and it is extremely common among uranium miners. [85]

2.9 Gamma Ray Interactions

There are three most important gamma ray interactions Compton scattering, photoelectric absorption, and pair production. These processes lead to the significant change of the original gamma-ray photon, both of the movement angle and the energy.[86]

2.9.1 Photoelectric Effect

In this process a photon is absorbed by an atom and the energy is transferred to an ejected electron photoelectron which is ejected from the atom from one of its bound shells, and in the process the photon completely disappears.

2.9.2 Compton Scattering of Gamma Photon

The Compton scattering is a scattering of the incident gamma ray photon and an electron in the absorbing material. In the general case this is the dominant interaction of typical gamma-ray energies. In Compton scattering the incident photon is deflected by angle θ with respect to its original direction [86]

2.9.3 Pair Production

This process, as shown on the diagram in Figure(2.3) is energetically possible if the γ-ray energy exceeds twice the rest mass of an electron that is 1.02 MeV.

Chapter Three

Experimental Part

3.1Introduction

Natural radioactivity has attracted many attention around the world, particularly in Iraq, because of its critical role in people's protection. The focus of this research was on determining the concentration of natural radioactivity in grain (rice and wheat) as well as in the soil. The samples were collected from Al- Shamiyah city, Al-Qadisiyah governorate in Iraq because most of the farms there are in there are supplying very much of the Iraqi grain specially rice in summer and wheat in winter . Furthermore, to determine the hazard indices for radionuclides that may affect human health, in order to observe the spread of cancerous diseases in some villages of the study area. We focused in this chapter on the selected study areas, the collected and preparation of samples and the preparation the devices and theoretical equation that using in calculating. Figure 3.1 the study's framework.

3.2 Research Area

Al-Shamiyah is a city in Iraq located about 180 kilometers south of Baghdad, the country's capital. It has a land size of (948) km^2 and is crossed by the river of AlShamiyah. It's located at ٣١° ٥٣'491" north 44 ° 59'889" east) [87]. As stated in Table 3.1 and Figure 3.1 sample of soil and grain (wheat and rice) are obtained of agricultural areas in 20 distinct regions from diverse locations for this study.

This city mainly depends on agriculture, as agriculture is the main engine of its economy, and one of the most important crops produced by the city is amber rice or Levantine amber, known to Iraq for its delicious flavor and sweet aroma, in addition to the cultivation of wheat and palm trees [88].

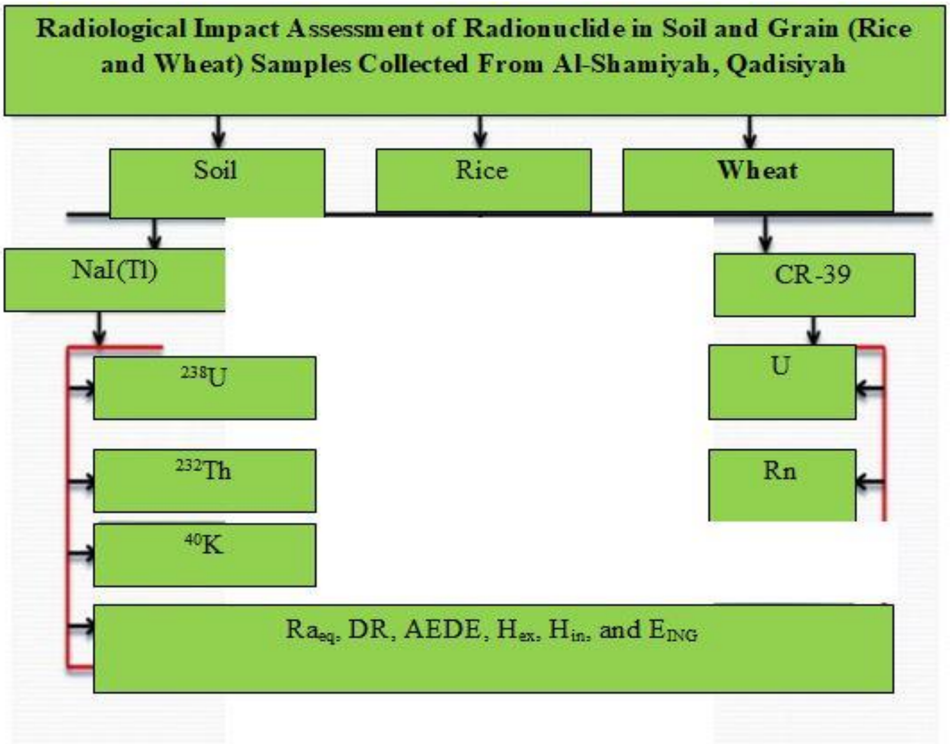

Figure 3.1 The studying framework

Table3.1 The names of regions and Coordinates of samples

L. No.	Locations	S. No.	Coordinates	
			Latitude (N)	Longitude (E)
1	AlJoboor	1	32°05'30599"	44°55'67371"
		2	32°0٦'٢٣99٢"	44°٣٩'٩٥١٢٥"
		3	32°0٧'٣٨١٧١"	44°٤٨'6٦٥١1"
		4	32°0٨'٤0٦٩٤"	44°٣٨'6٥١٤٣"
		5	32°0٩'٠٨١٩٢"	44°٥١'١٩٠٧٨"
2	Abo Kofoof	6	32°١٠'٧١٨٩٦"	44°٤١'67٤١٣"
		7	32°١١'٢١٨١٢"	44°٣٧'٩٦٧١٤"
		8	32°١١'٨٨١٩٧"	44°٣٥'٨٥٦٢1"
		9	32°١٢'٦٢٨٤١"	44°٣٥'6٢٨٤١"
		10	32°١٣'٠٧٧١٨"	44°٣٤'٢٨١٧٢"
3	AlHadadi	11	32°14'٦٣١٩٤"	44°3٤'51382"
		12	32°14'٨٥٢٩3"	44°3٤'٦٧٢٣١"
		13	32°14'٩٩٤١٨"	44°3٤'82١٦٣"
		14	32°1٥'١٠٩83"	44°3٤'٩٩٤٨١"

		15	32°1٥'٤٢٩٠٥"	44°3٥'١٨٢٦١"
4	Tabar Al-Zaweed	16	32°1٥'٦٨١٩٢"	44°3٥'٢2٠٩٥"
		17	32°1٥'٩٠٧١٦"	44°3٥'٤٢٦١٤"
		18	32°1٦'٠٠١23"	44°3٥'٥٢٩١٧"
		19	32°١٦'١٧٠٤٤"	44°32'5٤٣٩2"
		20	32°١٦'٤٩٠٧٣"	44°32'5٥٦٩١"
5	AlFilahi	21	32°١٦'٢٥١٤٢"	44°32'51702"
		22	32°٢٨'٣٣١٩٦"	44°32'49146"
		23	32°٣١'٤٩٠٧٣"	44°32'77261"
		24	32°٣٤'٤٧٥٧١"	44°32'83128"
		25	32°٣٥'٠١٠٧٣"	44°32'9180١"
6	AlChalakh	26	32°٣٥'٤٩٠٧٣"	44°33'14812"
		27	32°٣٥'٤٩٠٧٣"	44°33'27192"
		28	32°٣٦'١٢٩٥٣"	44°33'3٩١58"
		29	32°٣٦'٤٩١٧٩"	44°33'43662"
		30	32°٣٧'٤٩٠٧٣"	44°33'5147١"
7	AlNajaria	31	32°٤١'٤٩٠٧٣"	44°33'5٥482"
		32	32°١٦'٤٩٠٧٣"	44°33'59586"
		33	32°١٣'٣٧١٠٨"	44°33'6386١"
		34	32°١١'٧١٥٣٢"	44°33'66819"
		35	32°١٢'٤٤٨٧١"	44°33'77347"
8	AlGiratia	36	32°١٣'١٨٢١٣"	44°33'81539"
		37	32°١٤'٢٠٨١٧"	44°33'87092"
		38	32°١٤'٤١٣٧٣"	44°33'87926"
		39	32°١٦'٠٠٢٦١"	44°33'88107"
		40	32°١٣'٣٢٧١٦"	44°33'89033"
9	AlHafar	41	32°١٣'٠١٩٠٣"	44°34'08167"
		42	32°١٣'١١٣٧٣"	44°44'37614"
		43	32°١٣'٣٩٩٠٤"	44°44'68191"
		44	32°١٤'٧١٠٥٢"	44°47'19845"
		45	32°١٥'٤١٧٢٩"	44°45'88294"
10	Nodaiba	46	32°٠٦'١٠٨2٢"	44°45'46173"
		47	32°06'09473"	44°43'5٥٦77"
		48	32°٠٣'٥٧٩٠٢"	44°43'18746"
		49	32°٠٢'٧٣٩٤٥"	44°46'26172"
		50	32°٠١'١٢٩٦٧"	44°46'63582"
11	Goraisha	51	32°04'30916"	44°44'26419"
		52	32°05'11632"	44°44'44837"
		53	32°05'9735٣"	44°45'68118"
		54	32°04'94012"	44°46'82654"
		55	32°03'٤٩236"	44°47'23638"
12	AlOshr	56	32°٠٣'٣٣٦١٣"	44°48'04386"
		57	32°١2'61396"	44°48'37196"
		58	32°13'3318٣"	44°48'56109"

		59	32°١3'8٩11٣"	44°48'71986"
		60	32°١4'٤٩326"	44°49'93187"
13	AlGataa	61	32°11'٤٩٠37"	44°50'54164"
		62	32°١٦'25178"	44°50'89225"
		63	32°١5'61841"	44°51'48197"
		64	32°١5'22871"	44°52'39857"
		65	32°١٦'95٩٠٧"	44°53'5671١"
14	AlSada	66	32°١٦'٤1947"	44°56'39812"
		67	32°١7'3516٣"	44°63'81774"
		68	32°09'111٧٣"	44°64'41741"
		69	32°11'٤3371"	44°64'81748"
		70	32°05'11542"	44°62'62835"
15	Om AlWard	71	32°١٦'٤٩٠٧٣"	44°61'34716"
		72	32°08'3232٣"	44°62'79312"
		73	32°08'٤7348"	44°63'47826"
		74	32°09'٠٧٣65"	44°51'22917"
		75	32°09'٤٩664"	44°52'5٥376"
16	AlKhashania	76	32°١7'٤7195"	44°53'18713"
		77	32°١٦'34581"	44°53'78157"
		78	32°١8'22572"	44°54'26275"
		79	32°١٦'90263"	44°54'31894"
		80	32°١5'٤٩401"	44°55'37197"
17	Abo Gorban	81	32°00'٤9841"	44°55'69367"
		82	32°00'78105"	44°55'78297"
		83	32°00'93611"	44°55'81063"
		84	32°01'60131"	44°55'86398"
		85	32°01'51723"	44°55'97165"
18	AlHassan	86	31°99'61723"	44°70'11754"
		87	31°93'96361"	44°70'57181"
		88	31°92'68124"	44°66'39573"
		89	31°92'03611"	44°67'27184"
		90	31°91'36110"	44°72'61984"
19	Said Haboob	91	31°91'61335"	44°73'44972"
		92	31°91'21573"	44°73'71227"
		93	31°92'68124"	44°73'94816"
		94	31°93'05543"	44°74'17834"
		95	31°91'36629"	44°74'42168"
20	AlBasri	96	31°90'62618"	44°74'77164"
		97	31°90'76522"	44°74'97222"
		98	31°90'68471"	44°75'23763"
		99	31°90'46281"	44°75'57921"
		100	31°89'93877"	44°75'75697"

- S. No. in NaI(Tl) detection

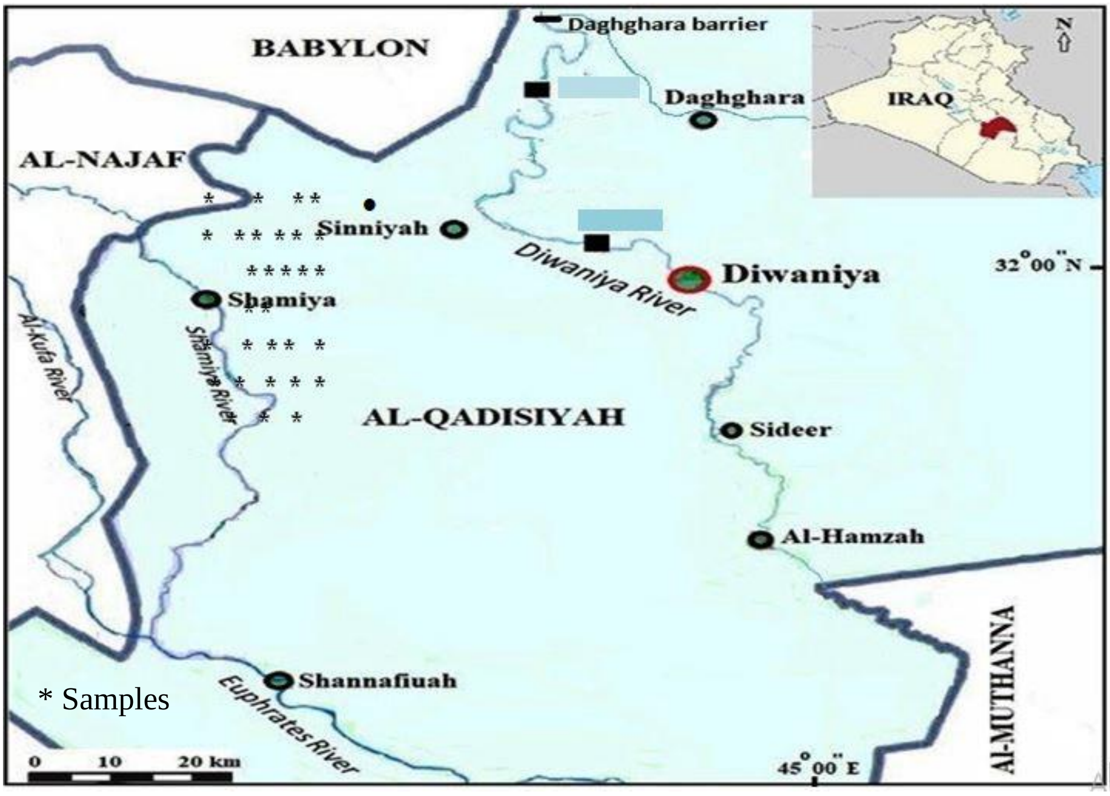

Figure 3.2 Qadisiyah Governorate and sample sites [87].

3.3 Preparation Samples

After collecting the samples for 20 different areas, made from farmland soil in various villages then prepared them. Figure 3.3 showed the method of Preparation samples.

NaI(Tl) [^{235}U, ^{232}Th and ^{40}K]

Soil	Rice	Wheat
- Cleaned the samples. - Dried in an oven at 100 °C. - Crushed the samples. - Sieved 2 mm mesh. -Stored at least for1 month - Weighted 1kg	-Grinded. - Cleaned the samples. - Dried in an oven at 100 °C. - Crushed the samples. - Sieved 2 mm mesh. -Stored at least for1 month - Weighted 1kg	-Grinded. - Cleaned the samples. - Dried in an oven at 100 °C. - Crushed the samples. - Sieved 2 mm mesh. -Stored at least for1 month - Weighted 1kg

CR-39 and Am-Br neutrons source, Active method[U]

Soil	Rice	Wheat

-Grinded.
- Cleaned the samples.
- Dried in an oven at 100 °C.
- Crushed the samples.
- Sieved 2 mm mesh.
-Stored at least for1 month
- Weighted 0.5g.
- mixed with 0.1gm of ($C_6 H_{10} O_5$) starch.
- pressed into a pellet of (1cm × 1.5 mm) diameter and thicken, respectively.

CR-39[^{222}Rn]

Soil	Rice	Wheat

-Grinded.
- Cleaned the samples.
- Dried in an oven at 100 °C.
- Crushed the samples.
- Sieved 2 mm mesh.
- Weighted 5g.
-Stored at least for 2 months

Figure 3.3 Diagram for samples preparation

3.4 Equipment

1. NaI (Tl) counter

2. CR-39 detector

3.4.1 NaI(Tl) Detection System

The NaI(Tl) system, detector which was used in this study is a 3"x3" crystal as shown in Figure 3.4. The crystal is encapsulated by an aluminum casing. This particular detector is designed with ORTEC Components, Inc. with a maximum numbers of channel is 4096 connected with ADC (Analog to Digital Convertor) unit. A design is such that the detector has a built in amplifier and uses its (Maestro32) software was used to implement the laboratory. to gain and high voltage settings with multi-channel Analyzer (MCA) attached at the back and a single USB cable connecting the MCA to a PC[89].

Figure 3.4 Sodium iodide detector system the restaurant thallium NaI (TI) (3 "× 3")

3.4.1.1 Energy Calibration for NaI (Tl) Detector

The calibration of energy for gamma ray spectroscopy is a relationship between the number of channels in a multichannel analyzer and gamma photon energy, which is critical for determining a form for radioactivity nuclides. calibration of energy can be carried out using (^{60}Co) that emit gamma rays of known energy precisely (1173 and1332) and then identifying the peak position in channels by using library function in program (Setting → Energy Calibration → 2point Calibrate) as shown in Figure: 3.5.

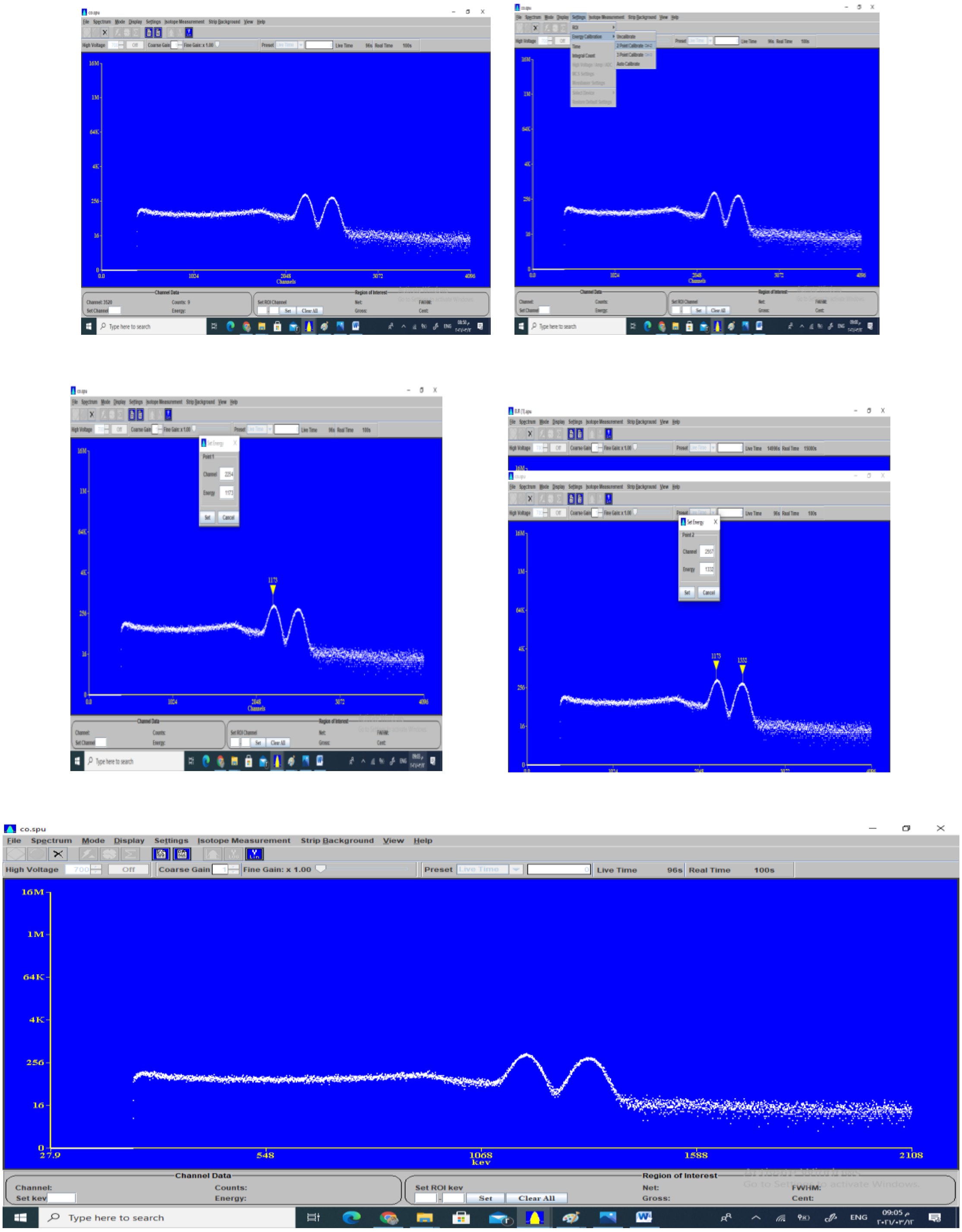

Figure 3.5 Energy calibration for NaI (Tl) detector

3.4.1.2 Absolute Efficiency

The counts per unit time and the total operation for a known norm are linked in the calibration of a detector's performance. For the measurement of the sodium detector's gamma ray detection effectiveness, calibration standards with a precisely limited quantity operation, traceable to national and international primary standards, can be purchased. Table 3.2 shows how mixed standard gamma sources were used to calibrate absolute performance. The equation (3.1) was used to calculate the absolute efficiency. [89,90]:

$$\varepsilon = \frac{C}{A.I_{\gamma}.t} \times 100\% \qquad 3.1$$

where:

C: area down photo peak, measurement time per second. I_γ : The percentage of the intensity of gamma rays emitted energy for each of the radioactivity source energies, A: Activity of samples of measured time. In this study, Figure 3.6 shows the performance of curve of the efficiency calibration for the NaI(Tl) detector.

Table 3.2 Standard sources with energies known and efficiency

No.	Isotopes	Energy(keV)	Efficiency %
1	^{22}Na	511	0.066
2	^{54}Mn	834	0.016
3	^{57}Co	122	0.288
4	^{60}Co	1173	0.029
5	^{60}Co	1332	0.022
6	^{109}Cd	88	0.411
7	^{155}Ba	383	0.061

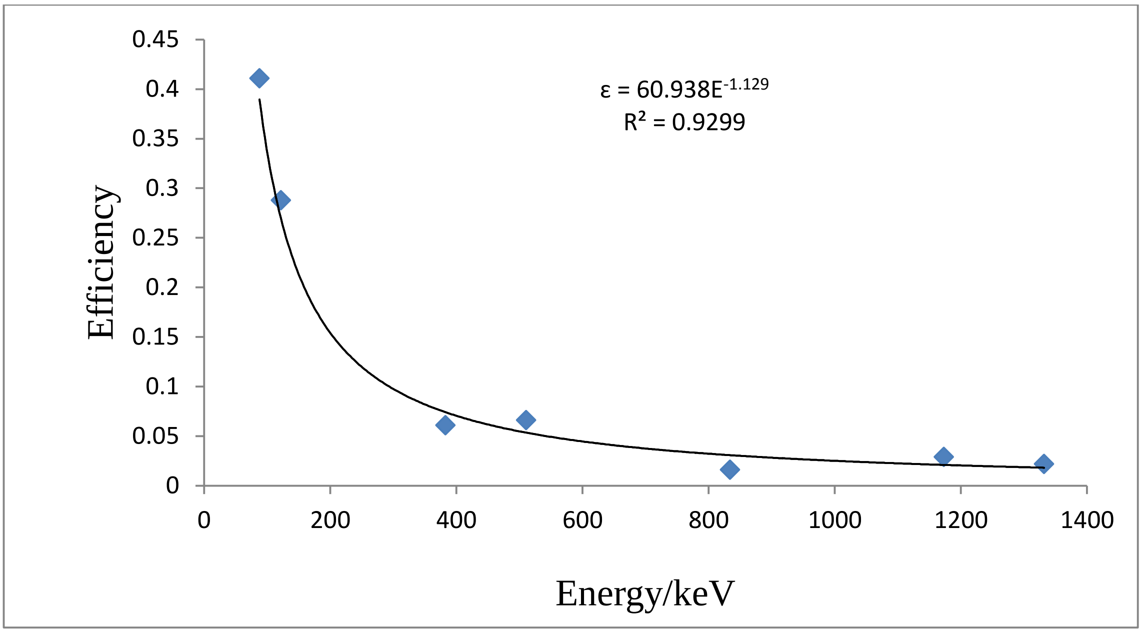

Figure 3.6 Calibration efficiency of NaI(Tl) detector.

Through the Figure 3.6 we find the relationship between efficiency and energy was represented by the following equation:

$\varepsilon = 60.938E^{-1.129}$..............................3.2

where: ε is represents the efficiency, E is representing the energy from equation(3.4), it can be found the efficiency in ^{238}U (^{214}Bi), ^{232}Th (^{208}Tl) and ^{40}K as seen in Table 3.4.

Table 3.3 The isotopes [^{238}U (^{214}Bi), ^{232}Th (^{208}Tl) and ^{40}K] efficiency values

Isotopes and Daughter	Energy (keV)	ε %
^{40}K	1460	0.016
$^{238}U(^{214}Bi)$	1764	0.013
$^{232}Th(^{208}Tl)$	2614	0.008

3.4.1.3 Background and Samples Measurement

Background is one of the most critical influences on the measurement the background spectrum was measured by a 1-liter plastic container on the detector and counting at the same time for sample measurements. Figure3.7 shows the background spectrum within the research laboratory in date 22/10/2019 measurement time of 15000 Second.

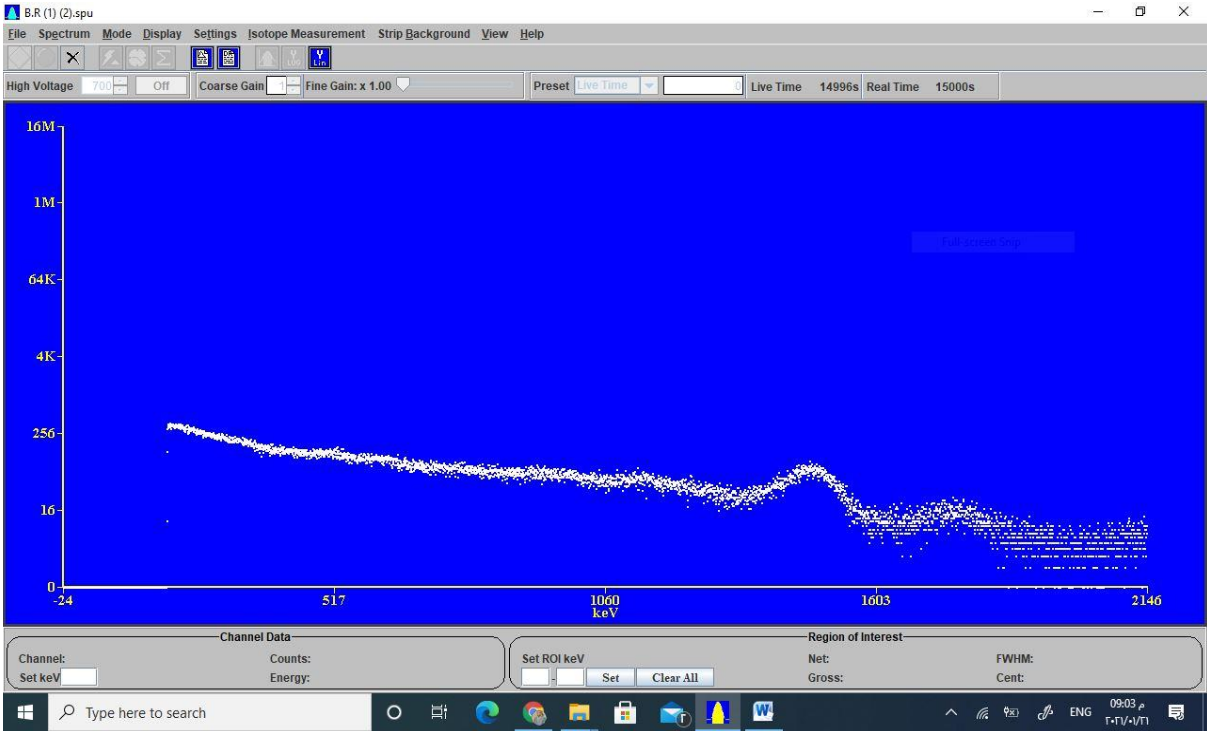

Figure: 3.7 Background spectrum by NaI(Tl) detector

Environmental samples of low-level radioactivity are often measured in marinelli beakers specially designed to provide better detection sensitivity. Full Energy Peak Efficiency (FEP) variations are observed in this geometry for different sample types this is due to self-attenuation effects, see Figure 3.8 for marinelli beaker photo and a drawing of its dimensions respectively.

The 1-liter Marinelli beaker made of polypropylene material, manufactured by Amersham was used. The precision with which the activity can be determined by this Marinelli geometry is limited by the effect of self-absorption for which correction must be made. Using the maestro-32 data analysis tool, a pure region down relevant highs of the scope of energy were calculated for each sample by deducting the number of counts due to sources of background from the net area of a specific peak.

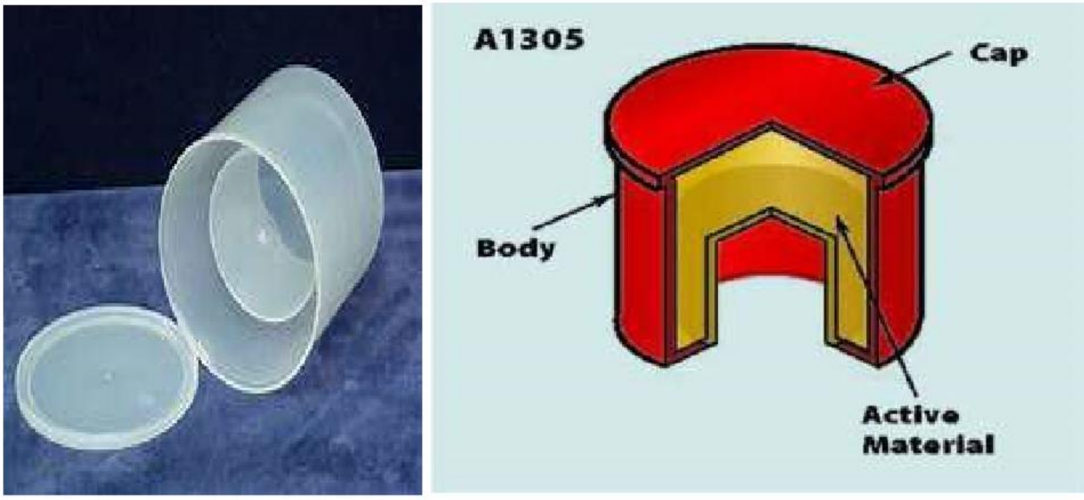

Figure3.8 Photo of marinelli beaker and the design of its geometry

For minimum photon of gamma energy with poorly split pic, the measurement of specific activity concentrations is conceivable; but, at high energies with well-separated photo-peaks, such as those observed in our data, the measurement of individual concentration levels is achievable. from photon of gamma generated by a daughters from uranium-238 and thorium-232 that also are in equilibrium of secular with each other while, pdtassium-40 is directly estimated from it is ray for gamma- of 1460 keV.

3.4.2 CR-39 Track Detector

CR-39 is an organic detector. Cartwright, Shirk and Price were discovered it in (1978). ($C_{12}H_{18}O_7$) represented the chemical composition for CR-39 is and (1.32 g.cm^{-3}) is the density for it. The CR-39 detector products can be made from a liquid monomer which is made by polymerization in the form of highly cross linked in to homo polymers, copolymers (usually methyl methacrylate and vinyl acetate) or intermediate products. The plastic CR-39 have a specific name called poly ally digital carbonate and supplied by a company of Pershore Molding, Ltd, England. As according " Columbia Resins " [91], a code CR-39 is assigned. As shown in Figure 3.9, the general structure of a molecule is made up of two groups of ally (CH2-CH=CH2-) [91].

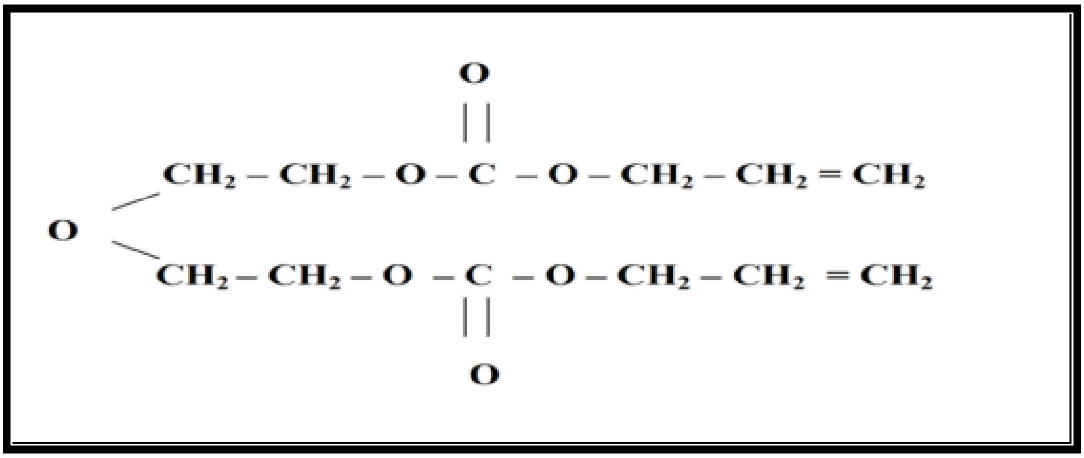

Figure 3.9 The chemical form of CR-39 plastic [91]

A detector (CR-39) has quite a highly efficient for recording tracks when used in conjunction with the other detectors, so it comes with several features including as:

1. It is transparent from an optical standpoint. Most sensitive to radioactivity.
2. it's symmetric and high homogeneous .
3. Never cross-linking after damage of radiation has broken the bonds of chemical.
4. Lack of a molecular etchant for the solution.
5. The polymer is almost impervious to the heating and all solvents. Use of the CR-39 plastic as a nuclear particles detector has become generalized in the measuring of dosing fields, spectroscopy and

science of environmental due to its high sensitivity. Most of the applications of this detector are in alpha particles, proton, and neutron and radiation image as well as for radon measuring of dosing and cosmic rays research [92].

3.4.2.1 Calibration Curves

The densities of the standard samples' reported induced tracks were tallied and shown as a function of U concentration.. All measurements were adjusted for the tracks densities of CR-39 detector. The calibration curves for the regular samples for soil and grain are given in Figures 3.10 and 3.11[44, 93,94] .

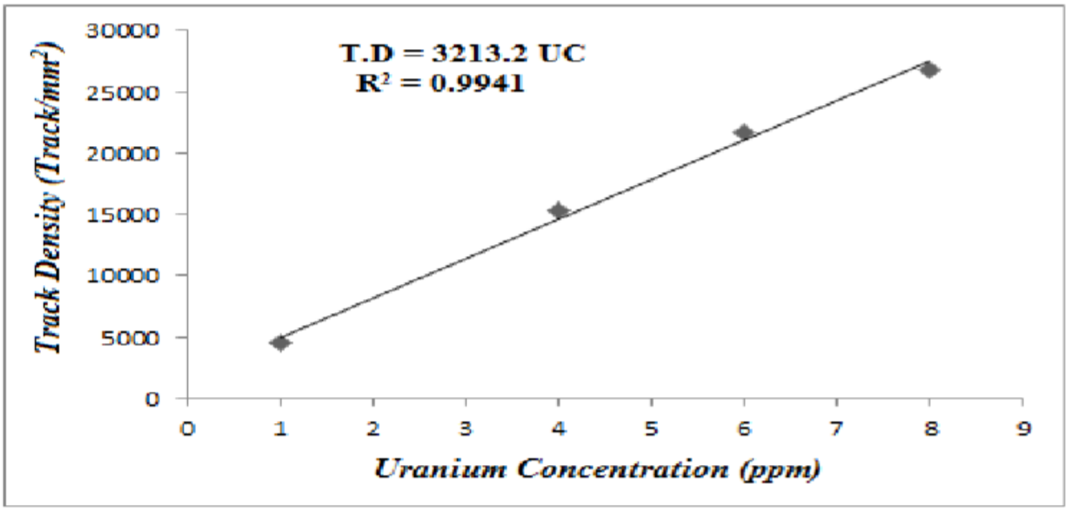

Figure3.10 Density of tracks and concentration of uranium (ppm) of the standard samples of soil [93,94]

3.5 Other Materials

3.5.1 Irradiation Source

Irradiation Source is device use to irradiation samples, it form of americium-beryllium neutron source with flux of neutrons is $3*10^5 n.cm^{-2}.s^{-1}$. It emits very speed neutrons with reaction of (α , n):

$$ {}^{9}_{4}Be + {}^{4}_{2}He \rightarrow {}^{12}_{6}C + {}^{1}_{0}n fast + 5.76\ MeV \qquad \ldots\ldots\ldots\ldots 3.4 $$

The irradiation system is made up of a tube from (^{241}Am- ^{9}Be) source encased in wax of paraffin. Wax of paraffin is using to moderate neutron's velocity to thermo-neutron ${}^{1}_{0}n$ thermal energies[95].

3.5.2 Etchant Solution

The etching procedure was carried out with a 6.25 N solution of sodium hydroxide (NaOH). An etchant method is created using a capillary tube and the formula[96] :

$$ W = W_{eq.} \times N \times V \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots..3.5 $$

where:

Wis mass of hydroxide of sodium was using in etchant solution

W_{eq} is mass equivalent of hydroxide of sodium

N is normality is 62.5

V is volume of distilled water is (0.250 l)

W_{eq} = 39.99711 g / mol.

So that:

$W = 62.5\ g$

The compartment of etchant has a volume 250 ml of solution of NaOH Using 6.25 N exclude of a tiny pipe at the upper edge of the cylinder pipe protects such a evaporation-induced change in acid solution normal life (intensity) during the experiment., this equipment is a closed assembly. The etching was done at 80 °C for six hours at a temperature of 70 °C.

3.5.3 Water Bath

Water bath (type Labsco, Germany) was used to regulate the etchant solution temperature. It contain a thermostat employment about a temperature between25 degrees Celsius and115 degrees Celsius with temp. regulating accuracy of less than 0.1 degrees Celsius. Chemical etching is done in 70 degrees Celsius. The bathing liquid was distilled water.

3.5.4 Optical Microscope

The optical microscope was used to count the compound etchant tracks (type Motic, Malaysia). It can provide high mag. of 400x and a lens adapter mag. of 10x to count no. of tracks..

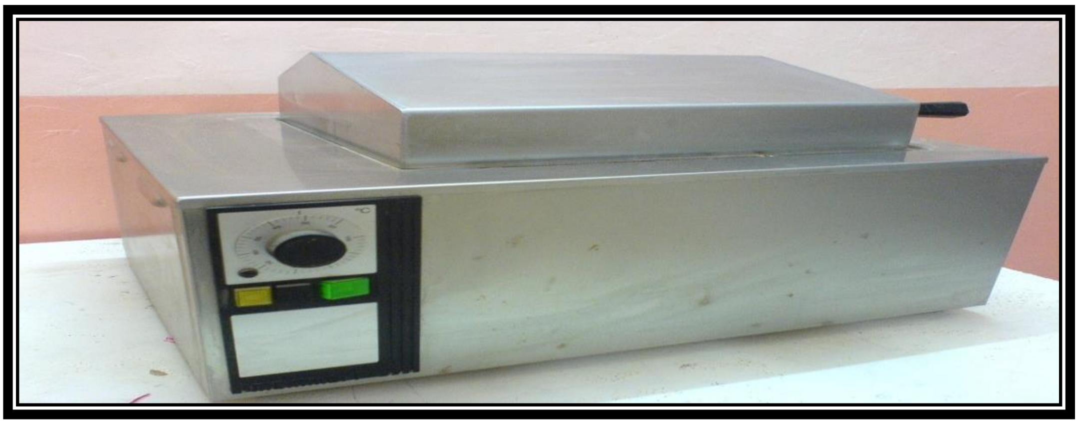

Figure 3.11 Water Bath

Figure 3.12 Optical Microscope

3.5.5 Sensitive Balance

The sensitive balance has been used to weight the soil sample and solid chemical materials to produce the etching solution .It is supplied by SARTORIUS Co .,Germany. Its sensitivity equals to (± 0.001 gm)[97] .

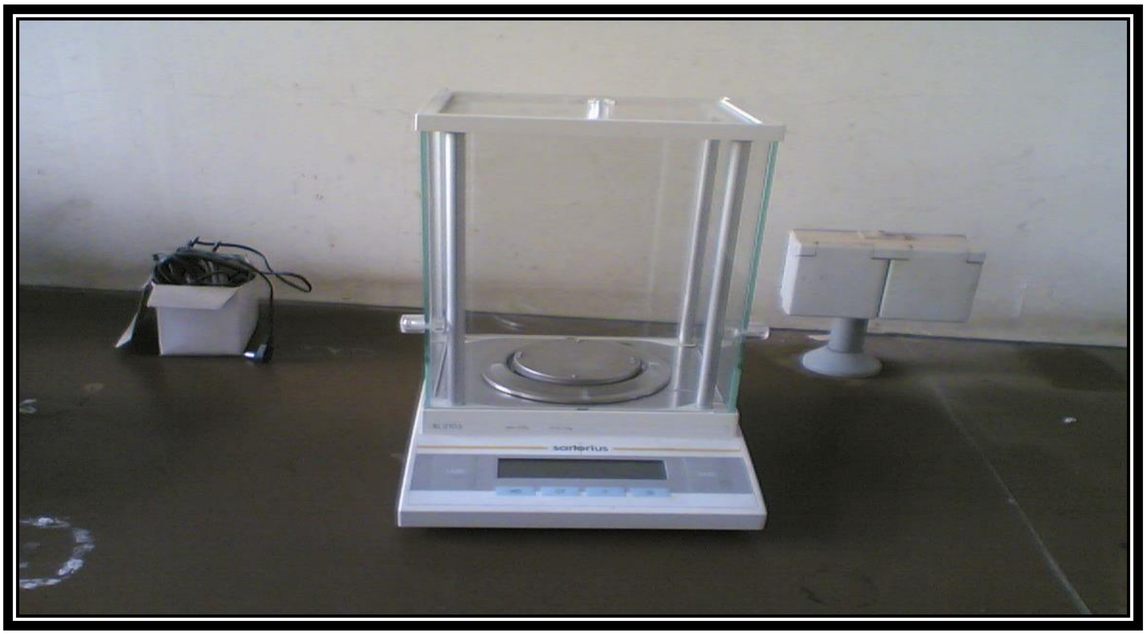

Figure 3.13 Sensitive balance

3.5.6 Sieve

The sieve been used to sieve the soil samples is supplied by Retsch Co., Germany. The size of the sieve opening is 75 µm.

3.5.7 Micrometer

Using a micrometer to measure thickness of the pellets is supplied by Germany.

3.5.8 Piston

Use the piston-type (Paul Weber) of the pressing force to very (15tons) and is used to press the samples to make a pellet in 13 mm diameter and1.5 mm thickness[98] **.**

3.5.9 Oven

The oven which is used to dry soil and grain (rice and wheat) samples is supplied by National Co., Japan .It has range from 0 to 220^{0}C.

3.6 Measurement Uranium and Radon Concentration by CR-39 Detector

3.6.1 Preparation Detector

A big sheet of CR-39 were carefully cut by sharp blades into small pieces of (1×1) cm^2 area, to measuring the alpha particles emitted from radon concentration, and fission tracks to measure concentrations of uranium samples. The detector of CR-39 which used for measuring the uranium concentration were installed with a pellet of samples, as (sandwich). While, the detectors that used to measure the radon was installed by adhesive tape inside the can lid[99].

3.6.2 Experimental Method

Uranium and radon concentrations were measured samples of soil and grain (rice and wheat) by the irradiation methods and PVC tube, respectively. Irradiation technique for measure uranium concentration soil and grain samples, all samples are irradiated by neutrons source. Where, the samples that were previously compressed were used; the pleats of soil and grain samples were (1cm, 1.5mm) diameter and thickness, respectively. This working was done in college of basic education university of Babylon, Iraq. This pleats placed between a two Pasic of (CR-39) detector with a distance (1×1) cm^2 , then it was bonded by sticker and labeled, then placed again on a long sticker (one ne after the other), as showed in Figure 3.15. After the finished from the samples preparation with detectors, they were taken to irradiation by neutron source from type (Am-Be) adorned with a heat transfer prance equivalent to (3024 × 10^{12} neutrons/ cm^2), the distance between the source and samples is 5 cm, they put on a plate of paraffin wax. In this process, the sandwich of CR-39 and pleat irradiated as spectrum of neutrons for 7 days to insure that most of U-atoms in samples will be decay in this period[100]. Where, the Americium (^{241}Am) source emits alpha particles, these particles interacted with the Beryllium (^{9}Be) and this lead to production neutrons through (α, n) reaction[101]:

$$^{241}_{95}Am \rightarrow {}^{4}_{2}\alpha + {}^{237}_{93}Np \qquad 3.6$$

$$^{9}_{4}Be + {}^{4}_{2}\alpha \rightarrow {}^{12}_{6}C + {}^{1}_{0}n_{fast.} + 5.71Mev \qquad \ldots\ldots\ldots\ldots.3.7$$

When that neutron enters to ^{235}U nucleus (with the relatively large thermal cross-section), the atom fissions into small atoms called 'fission fragments' through (n, f) reaction. When the fission fragment falls on the material of detector, It produces a fission track by breaking down the molecular structure of the material along its course.[102].

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{236}_{92}U^{*} \rightarrow ^{141}_{56}Br + ^{92}_{36}Kr + 3^{1}_{0}n \quad \text{.........3.8}$$

Or with the other mean:

$$^{1}_{0}n + ^{235}_{92}U \rightarrow fission\ fragments \qquad \text{..........3.9}$$

The irradiating process for samples was done in (Physics Department, Education for Pure Sciences / Ibn Al-Haitham College, University of Baghdad, Baghdad, Iraq).While, PVC tube is a long-tube technique to measure the radon concentration in soil and grain (rice and wheat) samples; it's made of (Poly Vinyl Chloride). is designing as of dimension 0.2 cm, 2.1cm, 10.5cm thick, diameter and length, respect. for measuring the Rn-222 cons. only reach CR-39 with no other gases[103]. The powder of samples (soil or grain) are located in top of tube then detector of CR-39 is installing by tape of adhesive on bottom of tube cover, then stored for 60 d for ensuring radioactivity nuclide which exist from samples reach state of equilibrium, as shown in Figure 3.16. Whenever a severely ions particles charge pass into these insulator substances, it rates a 50°A trail of changes in formations its wake. That’s known as a 'Latent Tracks' because it is not visible to the human eye. The precise nature of the chemical changes that occur at the damage site is determined by the charge and velocity for particles, structure chemical for material of detector and conditions of environmental such as temp. and press. By etching, these latent tracks can be enlarged and developed so that they can be viewed under an optical microscope. [104].

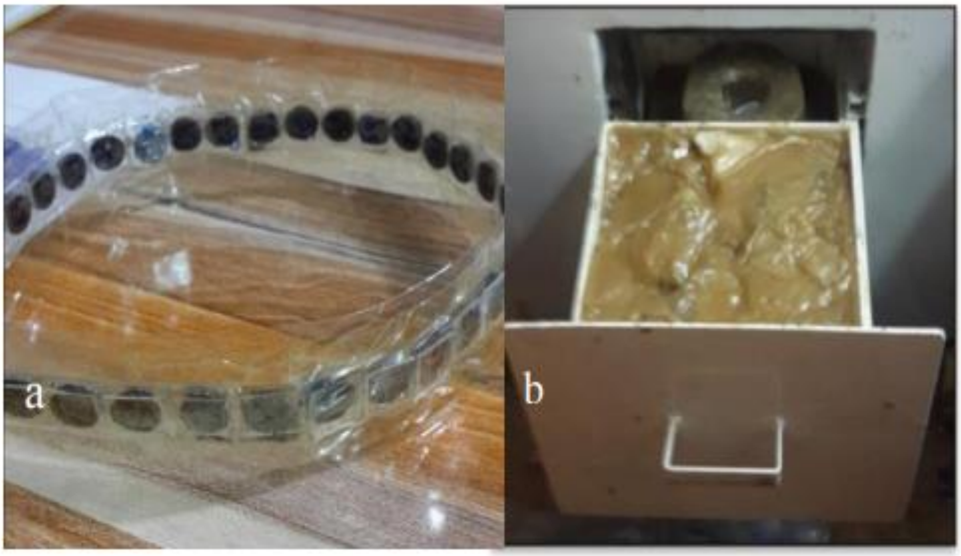

Figure 3.14 Irradiation method for determining concentration for U in samples of soil and grain (rice and wheat): (a) prepared for irradiation (b) and using the source of neutrons

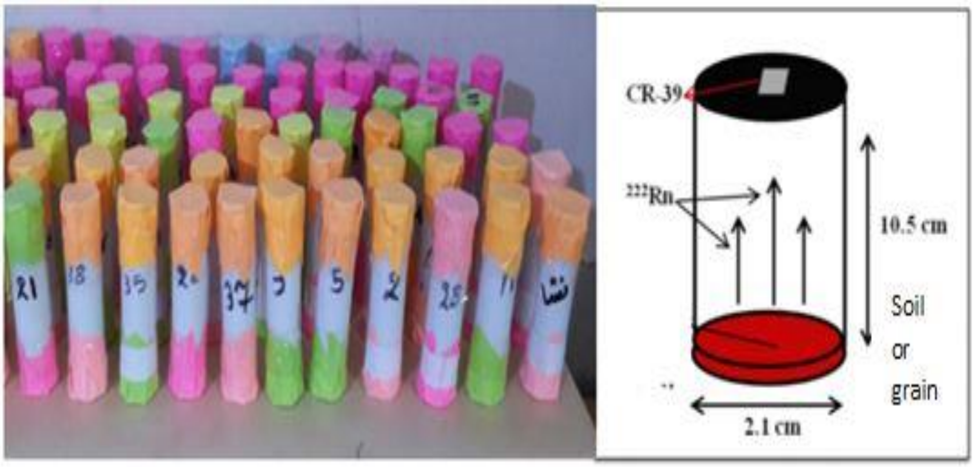

Figure3.١5 PVC tube to storage the soil or grain (rice and wheat) samples to measure the radon.

3.6.3 Preparation of NaOH Solution

After the irradiation process, the etching process begins of detectors CR-39 by solution of etching sodium hydroxide. 6.25 m/L liter from this solution (sodium hydroxide aqueous solution) was used as the etching solution to note tracks of latent on CR-39 results from the fission and process of decay at 70ºC for 8h[105]. After the samples have been irradiated, the etching technique is used. The equation was used to create this solution. 3.5 [106]:

The detectors were then thoroughly cleaned at room temperature for ten to twenty minimum in cold water, then etch in plain water for three min.[107], and then dried by fan.. A 400X magnification microscope was developed. then used to record the density of fission tracks. As shown in Figure, the density of the tracks was estimated using the formula in the following Figure. 3.17.

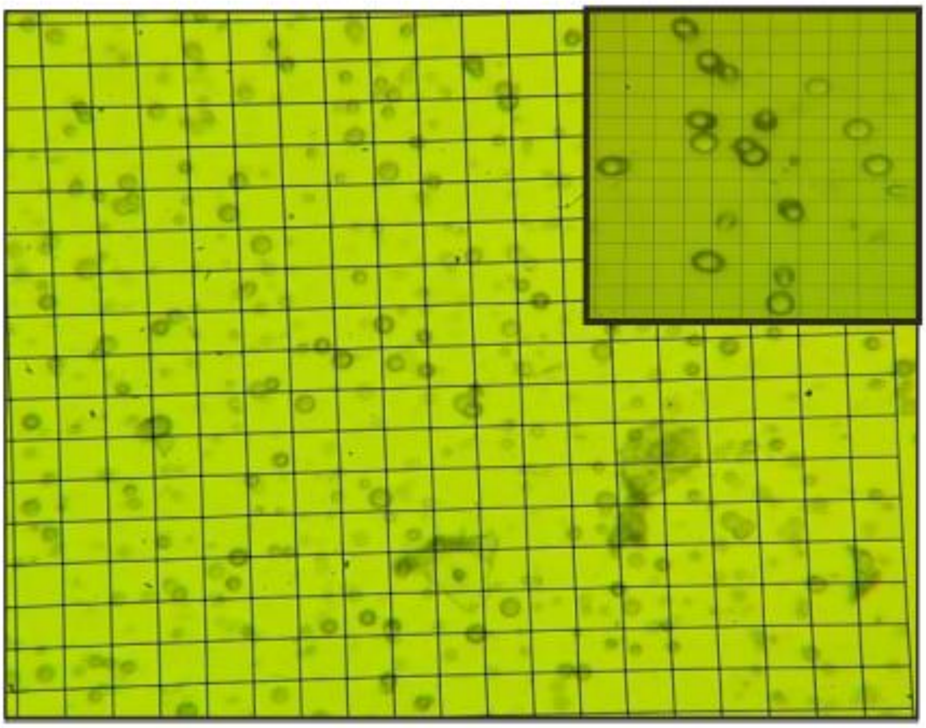

Figure 3.16 Tracks density on CR-39.

3.7 Theoretical equations

In this part the theoretical equations that using in the calculation of concentration and indices parameters for radioactivity, uranium and radon are measured.

3.7.1 Radiological Hazard Parameters

For evaluating the radiological hazards, the exposure to radiation arising from ^{238}U, ^{232}Th and ^{40}K in soil and grain (rice and wheat) can be calculated in expressions of a lot of parameters like equivalent of radium operation, hazard indices, dose rate, yearly outdoor effective dose equivalent, and the annual dose of intake from grain..

3.7.1.1 Specific Activity

The activity of uranium-238 in all samples was calculated using the energy peak of bismuth-214 (1764 keV); And in same road the activity of ^{232}Th was calculated using the peak of ^{208}Tl (2614 keV) and the activity of ^{40}K was calculated from the energy of (1460 keV). The analytical model used in determining the activity in Bq.kg^{-1} for soil and grain (rice and wheat) samples is shown in equation [108]:

$$A(Bq.Kg^{-1}) = \frac{N}{t \times \varepsilon \times I_{\gamma} \times m} \pm \frac{\sqrt{N}}{t \times \varepsilon \times I_{\gamma} \times m} \qquad \textbf{………….}3.10$$

where:

N: net. count under corresponding photo peak,

t : time of counting in second

I_{γ}: absolute transition gamma emission probability, m: sample mass (kg).

ε: efficiency of the detector in particular gamma energy

3.7.1.2 Radium Equivalent Activity (Ra_{eq})

The activity of equivalent 0f radium (Ra_{eq}) was used to refer a single quantity of the specific activity of ^{238}U, ^{232}Th and ^{40}K.

The Ra_{eq} is a critical metric for assessing radiation risks, and it can be calculated using formula[109]:

$$Rq_{eq}(Bq.kg^{-1}) = A_U + 1.43A_{Th} + 0.077A_K \quad \text{................3.11}$$

where: A_U, A_{Th} and A_K are the activity concentrations ($Bq.kg^{-1}$) of ^{238}U, ^{232}Th and ^{40}K respectively.

3.7.1.3 Dose Rate (DR)

There is clear connection between the natural radionuclides their exposure of it and the limited like the dose rate (DR). Assuming that naturally existing radionuclides are dispersed equally throughout the ground, the dosage rate at one meter above the ground surface can be calculated using the formula below. [71]:

$$DR = 0.461 \times A_U + 0.623 \times A_{Th} + 0.0414 \times A_K \quad \text{..........3.12}$$

where:

DR refers to absorbed dose rate with (nGy/h)
A_U, A_{Th} and A_K are the activity cons. (Bq/kg) of ^{238}U, ^{232}Th and ^{40}K respectively.

3.٧.1.4 Outdoor Effective Dose Equivalent on an Annual Basis (AEDE)

Because the dose rate one meter above the ground surface cannot used for determining annual dose equivalent dose (AEDE) from radioactive elements in the outdoors, the dose rate can using for determining the from natural radioactive in outdoors. [110]. Using the calculation below, the annual dosage equivalent dose was computed [2]:

$$AEDE = DR \times N_H \times O \times F \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.13$$

where:

The NH, O, and F represent for the no. of hour in a year (8.766×10^3), factor of outdoor occupancy (0.2) and dose absorbed in air to effective dose acquired by people, respectively (0.7 $Sv.Gy^{-1}$).

3.7.1.5 Indices of hazard

Index of hazard was appointed like the advice for radionuclides materials in the soil's maximum and grain (rice and wheat). This is to keep the radiation risk to a minimum. The risk of indexing is divided to internal and external, and symbol to them by H_{in} and H_{ex}[109]. The values of H_{in} and H_{ex} must be less than one to be considered negligible[2]

.3.7.1.5.1Internal Hazard Indices (H_{in})

The equation 3.14 is used to calculate the internal danger index of gamma ray activity concentrations in nature rad. of ^{238}U, ^{232}Th and ^{40}K respectively [109]:

$$H_{in} = \frac{A_U}{185} + \frac{A_{Th}}{259} + \frac{A_K}{5810} \leq 1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.١٤$$

where:

A_U, A_{Th} and A_K are cons. of activity (Bq/kg) for ^{238}U, ^{232}Th and ^{40}K respectively.

3.7.1.5.2External Hazard Indices (H_{ex})

The equation 3.15 is used to calculate the external danger index of gamma ray activity concentrations in natural radioactivity of ^{238}U, ^{232}Th and ^{40}K [109]:

$$H_{ex} = \frac{A_U}{370} + \frac{A_{Th}}{259} + \frac{A_K}{5810} \leq 1 \qquad \ldots\ldots\ldots\ldots\ldots\ldots 3.15$$

where:

A_U, A_{Th} and A_K are cons. of activity ($Bq.kg^{-1}$) of ^{238}U, ^{232}Th and ^{40}K respectively.

3.7.1.6 Ingestion Dose

The annual ingestion dose (E_{ING}) for man was coming from consumption of grain (rice and wheat) .The E_{ING} was calculated using following Equation given by[111]:

$$E_{ING} = A_I \times C \times FDC_{ING} \qquad \ldots\ldots\ldots\ldots\ldots\ldots 3.16$$

where :

E_{ING} : annual ingestion dose (μSv/y), A_I : activity cons. (Bq /kg$^-$) of investigated radioactivity in grain, C : average of consumption (kg/y) and FDC_{ING} : ingestion dose coefficient of ^{238}U, ^{232}Th and ^{40}K which was 0.2, 0.23 (μSv/Bq) and 6.2 (nSv/Bq) respectively.

3.7.2 Concentration of Uranium and Radon

3.٧.2.1 Concentration of Uranium

The concentrations for U in soil and grain samples are calculated by comparing the detector track densities for these samples to the density of tracks in standard samples that had been produced in advance. by[102,104]for soil and grain respectively as given below:

$$\frac{C_X}{C_S} = \frac{\rho_X}{\rho_S} \qquad \ldots\ldots\ldots\ldots\ldots\ldots 3.17$$

where:

ρ_x is the density of tracks for studying samples (tracks/mm ^{2})

ρ_s is the density of tracks for stand. samples (tracks/mm ^{2})

C_s is the concentrations for uranium for stand. (ppm)

C_x is the concentrations of uranium for unknown samples (ppm).

3.7.2.2 Concentrations of Radon

After 60 days of exposure of the soil and grain (rice and wheat) samples, the detectors CR-39 from all the cans were retrieved and with 6.25 N from NaOH at 70°C with etching time about 8 h[112,113]. After etching, washing and drying. The tracks numbers in 30 fields were examined for every detector by an optical microscope with 400X[114]. detectors from CR-39 record the no. of α-particles tracks that emitted from the gas of radon.

$$C_{Rn} = \frac{\rho}{k \times t} \qquad \ldots\ldots\ldots\ldots\ldots 3.18$$

where, (ρ) density of tracks (tracks/ m^2), (t) storage time and (k) is factor of calibration of CR-39 and has an estimation of 0.212 (tr/cm^2 per Bq/m^3.d)[2] where the fission track densities was measured by unity the following form[115]:

$$\rho(\frac{tr}{cm^2}) = \frac{N_{av.}}{A} \quad \text{.........................3.19}$$

where:

$N_{av.}$: the mean no. of tracks on surface of the detector,

A: the view visible area of field under microscope (4×4 grids area = 0.002704 mm^2).

3.7.3 Calculating Transfer Factor

To calculate transfer factor TF soil-to grain use following equation [116-118]:

$$TF = \frac{A_G}{A_S} \quad \text{................3.20}$$

where: A_G: Activity cons. for grain (Bq/kg or ppm dry weight).

A_S: Activity cons. for soil (Bq/kg or ppm dry weight).

Chapter Four
Results and Discussion

4.1 Introduction

Because of their radiological dangers, studying terrestrial radionuclides is crucial. The primary source of these radioactivity nuclides is soil. Radioactivity nuclides can enter the food chain through soil and eventually reach humans. into human beings.

4.2 Specific Activity

The ^{238}U, ^{232}Th and ^{40}K concentrations in soil and frequently grown grain (rice and wheat) from 20 different farms in Al-Shamiyah. The results of natural radioactivity are presented in Tables 4.1, 4.2 and 4.3 for soil, rice and wheat respectively as well as Figures 4.1, 4.2 and 4.3 respectively. From Table 4.1 the minimum and maximum activity for ^{238}U, ^{232}Th and ^{40}K for soil were found from 2.504±0.275 Bq.kg^{-1} in Om Al-Ward to 15.626±0.687 Bq.kg^{-1}in Al-Joboor with average 7.774±0.465 Bq.kg^{-1}, from0.439±0.101Bq.kg^{-1} in Abo Gorban to 5.116±0.344 Bq.kg^{-1} in Al-Giratia with average 2.301±0.217 Bq.kg^{-1} and from 199.371±2.799 Bq.kg^{-1} in Abo Gorban to 395.873±3.944 Bq.kg^{-1}in Al-Chalakh with average 270.985±3.322 Bq.kg^{-1} respectively. From Table 4.2 the maximum and minimum activity for U-238, Th-232 and K-40 in rice were found from 0.031±0.031Bq.kg^{-1} in Al-Najaria to 0.905±0.165 Bq.kg^{-1}in Al-Chalakh with average 1.383±0.179 Bq.kg^{-1}, from Bq.kg^{-1} in Al-Giratia 0.023±0.023 Bq.kg^{-1} in Al-Sada to 0.903±0.144 Bq.kg^{-1} in Al- Bq.kg^{-1} and from 2.279±0.299 with average 0.361±0.086 Hafar to 73.546±1.701Bq.kg^{-1}in Al-Joboor with average21.136±0.838 Bq.kg^{-1} respectively. While From Table 4.3 the minimum and maximum activity for ^{238}U, ^{232}Th and ^{40}K for wheat are found from

0.231±0.073Bq.kg^{-1} in Al-Khashania to 3.861±0.341Bq.kg^{-1}in Al-Basri Bq.kg^{-1}, from 0.255±0.077 Bq.kg^{-1} in Al- with average 3.651±0.319 Bq.kg^{-1} in Said Haboob with average Joboor to 1.597±0.192 0.752±0.126Bq.kg^{-1} and from 10.535±0.632Bq.kg^{-1} in Abo Gorban to 92.885±0.741 Bq.kg^{-1}in Al-Hassan with average 50.882±1.382 Bq.kg^{-1} respectively. The quantity of ^{238}U is almost larger than the quantity of ^{232}Th in all the study samples. In this study, the ^{40}K is larger than the quantity of ^{238}U, ^{232}Th. From the results note the quantity of these radioactivity nuclides observed in the soil and grain (rice and wheat) in Al-Shamiyah ,Qadisiyah in Iraq. The samples were discovered to be in the following order: soil > wheat > rice.

Table 4.1 Specific activity for radioactivity on soil in AlShamiyah city

No.	Location	Activity Concentration (Bq.kg^{-1})		
		^{238}U	^{232}Th	^{40}K
1	AlJoboor	15.626±0.687	2.106±0.221	364.269±3.784
2	Abo Kofoof	6.395±0.439	4.468±0.322	318.553±3.539
3	AlHadadi	10.226±0.555	2.639±0.247	322.642±3.561
4	Tabar AlZaweed	6.787±0.452	1.296±0.173	273.899±3.281
5	AlFilahi	14.178±0.654	2.384±0.235	338.836±3.649
6	AlChalakh	7.873±0.487	0.879±0.143	395.873±3.944
7	AlNajaria	2.866±0.294	3.449±0.283	234.159±3.034
8	AlGiratia	5.189±0.396	5.916±0.344	325.314±3.576
9	AlHafar	6.214±0.433	3.194±0.272	203.145±2.826
10	Nodaiba	2.504±0.275	5.833±0.367	292.021±3.388
11	AlAin	15.535±0.685	0.787±0.135	273.742±3.281
12	AlOshr	2.353±0.266	1.042±0.155	227.516±2.991
13	AlGataa	8.175±0.497	1.805±0.204	243.318±3.093

14	AlSada	9.261±0.529	0.532±0.111	300.118±3.435
15	Om AlWard	2.004±0.275	1.181±0.165	291.431±3.385
16	AlKhashania	15.354±0.681	3.889±0.301	242.531±3.088
17	Abo Gorban	5.913±0.422	0.439±0.101	199.371±2.799
18	AlHassan	6.848±0.454	1.782±0.203	328.459±3.593
19	Said Haboob	3.499±0.325	2.546±0.242	248.113±3.123
20	AlBasri	8.175±0.497	0.648±0.122	238.915±3.065
Max.		15.626±0.687	5.116±0.344	395.873±3.944
Min.		2.504±0.275	0.439±0.101	199.371±2.799
Ave.		7.774±0.465	2.301±0.217	270.985±3.322
Worldwide[2]		35	30	400

Table 4.2 Specific Activity for radioactivity on rice in AlShamiyah city

No.	Location	Activity Concentration ($Bq.kg^{-1}$)		
		^{238}U	^{232}Th	^{40}K
1	AlJoboor	0.513±0.124	0.162±0.061	73.546±1.701
2	Abo Kofoof	0.061±0.043	0.509±0.109	9.5126±0.611
3	AlHadadi	0.255±0.077	0.255±0.077	13.758±0.735
4	Tabar AlZaweed	0.456±0.117	0.093±0.046	18.357±0.849
5	AlFilahi	0.633±0.138	0.208±0.069	49.646±1.397
6	AlChalakh	0.905±0.165	0.116±0.052	56.643±1.492
7	AlNajaria	0.031±0.031	0.648±0.122	9.473±0.611
8	AlGiratia	0.543±0.128	0.718±0.129	43.475±1.307
9	AlHafar	0.241±0.085	0.185±0.065	2.279±0.299
10	Nodaiba	0.332±0.101	0.972±0.151	11.832±0.682
11	AlAin	0.556±0.113	0.231±0.073	3.931±0.393

12	AlOshr	0.754±0.151	0.694±0.127	14.387±0.752
13	AlGataa	0.509±0.109	0.046±0.033	10.849±0.653
14	AlSada	0.456±0.117	0.023±0.023	20.991±0.908
15	Om AlWard	0.255±0.077	0.301±0.083	9.906±0.624
16	AlKhashania	0.754±0.151	0.556±0.113	16.863±0.814
17	Abo Gorban	0.046±0.033	0.069±0.041	7.389±0.539
18	AlHassan	0.069±0.041	0.394±0.095	46.029±1.345
19	Said Haboob	0.091±0.052	0.903±0.144	10.495±0.642
20	AlBasri	0.394±0.095	0.139±0.057	4.206±0.407
Max.		0.905±0.165	0.903±0.144	73.546±1.701
Min.		0.031±0.031	0.023±0.023	2.279±0.299
Ave.		1.383±0.179	0.361±0.086	21.136±0.838

Table 4.3 Specific Activity for radioactivity on wheat in AlShamiyah city

No.	Location	Activity Concentration (Bq.kg^{-1})		
		^{238}U	^{232}Th	^{40}K
1	AlJoboor	0.625±0.121	0.255±0.077	77.594±1.746
2	Abo Kofoof	1.065±0.157	0.648±0.123	13.954±0.741
3	AlHadadi	0.532±0.111	0.856±0.141	29.324±1.074
4	Tabar AlZaweed	2.805±0.29١	0.532±0.111	45.912±1.343
5	AlFilahi	3.469±0.323	0.625±0.121	59.513±1.529
6	AlChalakh	2.896±0.296	0.301±0.083	76.651±1.736
7	AlNajaria	1.207±0.191	1.157±0.164	41.785±1.282
8	AlGiratia	0.935±0.168	0.811±0.137	61.675±1.557
9	AlHafar	1.448±0.209	1.065±0.157	34.866±1.171
10	Nodaiba	1.508±0.213	1.644±0.195	55.621±1.479
11	AlAin	4.133±0.353	0.879±0.143	53.184±1.446

12	AlOshr	1.388±0.205	0.926±0.146	46.619±1.354
13	AlGataa	3.017±0.302	0.139±0.059	53.616±1.452
14	AlSada	3.771±0.337	0.231±0.073	45.362±1.335
15	Om AlWard	3.559±0.328	0.486±0.106	69.182±0.412
16	AlKhashania	0.231±0.073	0.903±0.145	43.318±0.232
17	Abo Gorban	2.142±0.254	0.278±0.081	10.535±0.632
18	AlHassan	0.278±0.081	1.319±0.175	92.885±0.741
19	Said Haboob	0.879±0.143	1.597±0.192	56.053±0.627
20	AlBasri	3.861±0.341	0.394±0.095	50.001±0.607
Max.		3.861±0.341	1.597±0.192	92.885±0.741
Min.		0.231±0.073	0.255±0.077	10.535±0.632
Ave.		3.651±0.319	0.752±0.126	50.882±1.382

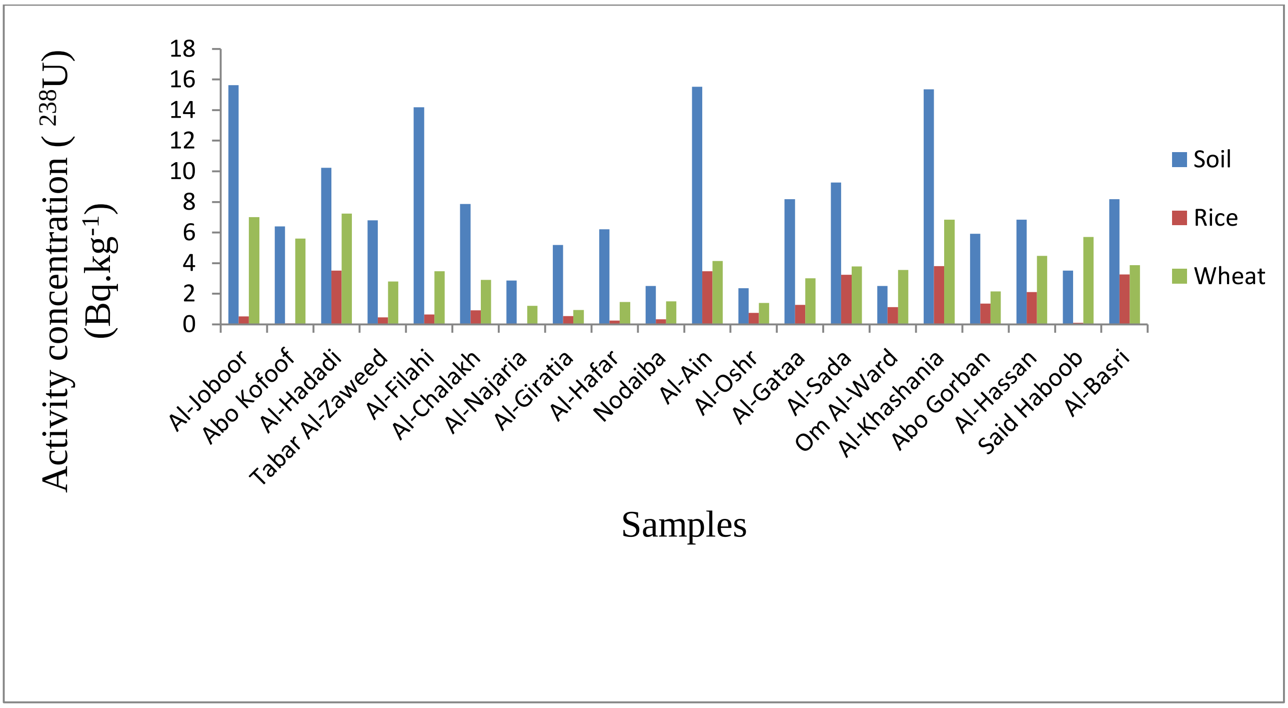

Figure 4.1 Specific activity for ^{238}U in soil and grain (rice and wheat) samples in AlShamiyah city

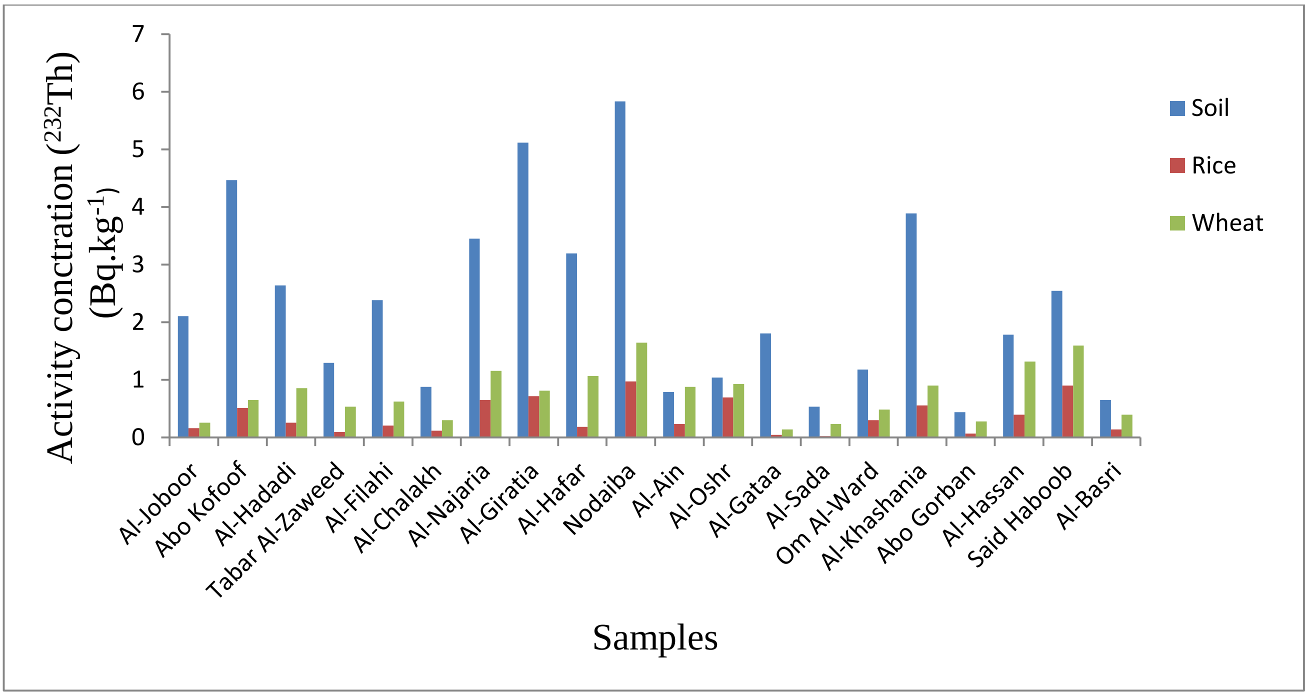

Figure4.2 Specific activity for ^{232}Th in soil and grain (rice and wheat) samples in AlShamiyah city

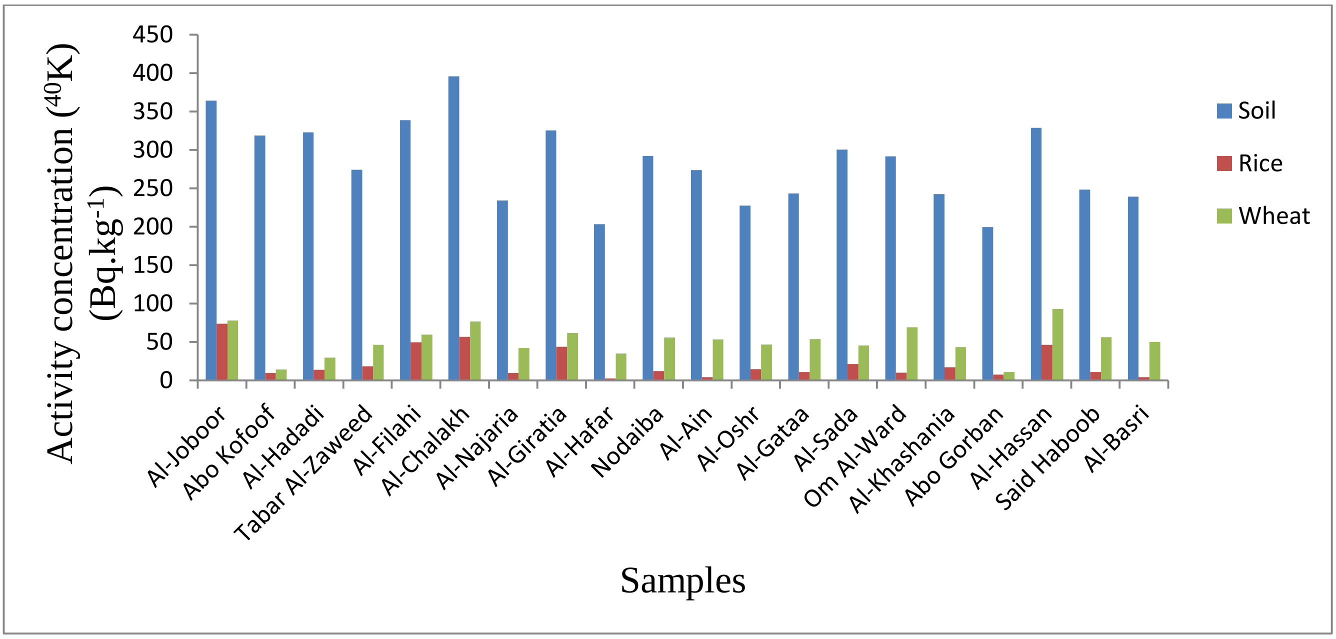

Figure 4.3 Specific activity for ^{40}K in soil and grain (rice and wheat) samples in AlShamiyah city

From Table 4.4 showed a comparison between concentration of radiological nuclide in soil obtain in present study and them in other studies. the highest concentration for ^{238}U and ^{232}Th in soil less than

Thailand, Nigeria, Kazakhstan and Bangladesh but concentration of ^{40}K is larger than in it.

Table 4.4 Comparison between concentration of radiological nuclide in soil obtain in present study and them in other studies.

Country	^{238}U	^{232}Th	^{04}K	Ref.
Thailand	30	25	230	[2]
Nigeria	30	25	370	
Kazakhstan	37	60	300	
Egypt	9.07	5.83	44.81	[119]
Bangladesh	24	19	360	[120]
India	57	87	134	[121]
Al-Basrah	11.9	41.1	499.2	[122]
Al-Najaf	23.59	12.10	60.68	[123]
Al-Qadisiyah	2.87	25.195	170.895	[124]
AlShamiyah city	7.774±0.465	2.301±0.217	270.985±3.322	[Present Work]
Worldwide	35	30	400	[2]

From Table 4.5 showed a comparison between concentration of radiological nuclide in grain (rice and wheat) obtain in present study and them in other studies. the highest concentration for ^{238}U, ^{232}Th and ^{40}Kin grain (rice and wheat)less than Kampung Permatang Tok Brain Kampung Pantai Kemelun, but larger than in Erbil and Kampung Guar Tuan Said.

Table 4.5 Comparison between concentration of radiological nuclide in grain (rice and wheat) obtain in present study and them in other studies.

Region	Grain	^{238}U	^{232}Th	^{04}K	Ref.
Erbil	Rice	0.36 ± 0.09	0.11 ± 0.02	68.07 ±4.91	[81]
	Wheat	0.63 ± 0.19	0.25 ± 0.05	153.72 ± 11.78	
Kampung Permatang Tok Brain	Rice	1.89	1.52	69.8	[125]
Kampung Guar Tuan Said		0.85	0.66	62.79	
Kampung Pantai Kemelun		2.15	0.99	105.23	
Al- Shamiyah city	Rice	1.3831±0.179	0.361±0.086	21.136±0.838	[Present Work]
	Wheat	3.651±0.319	0.752±0.126	50.882±1.382	

4.3 Radiation hazards

The highest radium equivalent activity were found in the Tabar Al-Zaweed and AlJoboor in soil and grain to be 43.678 $Bq.kg^{-1}$, 6.408 $Bq.kg^{-1}$ and 13.337 $Bq.kg^{-1}$respectively; whereas the lowest radium equivalent activity were found in the other soil and grain to be 21.361 $Bq.kg^{-1}$, 0.682 $Bq.kg^{-1}$ and 3.351$Bq.kg^{-1}$in Al-Ain, Al-Hafar and Al-Khashania respectively. Based on the results, the amount of ^{238}U, ^{232}Th and ^{40}K observed in Al- Shamiyah farms is larger than the farm in Erbil. Activity of radium equivalent (Ra_{eq}) , internal and external hazard indices (H_{in} , H_{ex}), dose rate (DR), annual outdoor effective dose equivalent (AEDE), annual outdoor effective dose equivalent (AEDE), annual outdoor effective dose equivalent (AEDE), annual outdoor effective dose equivalent (AEDE), annual outdoor effective dose equivalent (AEDE) and were computed and tabulated in Tables:4.6, 4.7, 4.8, 4.9, 4.10 and 4.11 respectively. In Al- Shamiyah , Ra_{eq}, DR, AEDE, H_{in}, and H_{ex} average values were discovered to be (32.863, 3.569 and 8.644) $Bq.kg^{-1}$ (6.378, 1.011 and 2.509) $nGy.h^{-1}$,(7827.009, 1239.918 and 1594.323)mSv, (0.109, 0.013 and 0.033) and (0.089, 0.009 and 0.023) for (soil, rice and wheat) respectively. From these results the equivalent activities of radium were less than 370 $Bq.kg^{-1}$ that is safety stage [126]. The results of (DR) mean are less than 59 $nGyh^{-1}$ and the values of H_{in} and H_{ex} are less than unity[2].

Table 4.6 Radium equivalent activity (Ra_{eq}) in samples of soil and grain (rice and wheat) in AlShamiyah city.

No.	Location	$Ra_{eq}(Bq.kg^{-1})$		
		Soil	Rice	Wheat
1	AlJoboor	37.312	6.408	13.337
2	Abo Kofoof	38.843	1.521	7.612
3	AlHadadi	29.731	4.923	10.723
4	Tabar AlZaweed	43.678	1.998	7.102
5	AlFilahi	39.613	4.754	8.945
6	AlChalakh	25.828	5.432	9.228
7	AlNajaria	37.553	1.686	6.079
8	AlGiratia	26.424	4.917	6.843
9	AlHafar	33.331	0.682	5.655
10	Nodaiba	37.739	2.633	8.141
11	AlAin	21.361	4.103	9.486
12	AlOshr	29.492	2.855	6.301
13	AlGataa	33.131	2.169	7.344
14	AlSada	26.632	4.877	7.595
15	Om AlWard	39.591	2.309	9.582
16	AlKhashania	21.893	5.894	11.474
17	Abo Gorban	34.687	2.026	3.351
18	AlHassan	26.245	6.219	13.504
19	Said Haboob	27.498	2.189	12.302
20	AlBasri	37.312	3.781	8.274
Max.		**43.687**	**6.408**	**13.504**

Min.	**21.361**	**0.682**	**3.351**
Ave.	**32.863**	**3.569**	**8.644**
Worldwide[126]	**370**	**370**	**370**

Table 4.7 Dose rate (DR) for samples of soil and grain (rice and wheat) in AlShamiyah city.

No.	Location	DR($nGy.h^{-1}$)		
		Soil	**Rice**	**Wheat**
1	AlJoboor	10.449	0.603	3.937
2	Abo Kofoof	7.276	0.408	3.306
3	AlHadadi	7.966	1.976	4.315
4	Tabar AlZaweed	5.167	0.349	1.919
5	AlFilahi	9.829	0.619	2.359
6	AlChalakh	5.818	0.714	1.905
7	AlNajaria	4.539	0.488	1.529
8	AlGiratia	7.134	0.901	1.219
9	AlHafar	5.949	0.255	1.565
10	Nodaiba	6.168	0.868	2.056
11	AlAin	9.215	1.913	2.846
12	AlOshr	2.618	0.898	1.477
13	AlGataa	6.115	0.703	1.781
14	AlSada	5.973	1.704	2.197
15	Om AlWard	2.992	0.798	2.341
16	AlKhashania	11.141	2.342	4.194
17	Abo Gorban	3.906	0.753	1.299
18	AlHassan	5.703	1.476	3.439
19	Said Haboob	4.286	0.695	4.133
20	AlBasri	5.311	1.745	2.368
Max.		**11.141**	**2.342**	**4.315**
Min.		**2.618**	**0.255**	**1.219**
Ave.		**6.378**	**1.011**	**2.509**

Table 4.8 Annual outdoor effective dose equivalent (AEDE) for samples of soil and grain (rice and wheat) in AlShamiyah city.

No.	Location	AEDE(m.Sv)		
		Soil	**Rice**	**Wheat**
1	AlJoboor	12823.107	739.574	4831.774
2	Abo Kofoof	8929.669	500.778	4056.701
3	AlHadadi	9776.731	2424.521	5295.611
4	Tabar AlZaweed	6341.673	428.326	2355.093
5	AlFilahi	12063.408	759.232	2895.005

6	AlChalakh	7139.586	876.478	2337.345
7	AlNajaria	5570.658	598.307	1876.451
8	AlGiratia	8754.795	1105.656	1496.168
9	AlHafar	7300.659	312.755	1920.659
10	Nodaiba	7569.995	1064.849	2523.559
11	AlAin	11308.478	2348.095	3492.613
12	AlOshr	3212.938	1102.672	1813.159
13	AlGataa	7503.962	862.372	2185.965
14	AlSada	7329.837	2091.621	2696.173
15	Om AlWard	3672.264	978.868	2872.352
16	AlKhashania	13671.729	2874.604	5147.327
17	Abo Gorban	4793.657	924.017	1594.323
18	AlHassan	6999.305	1811.491	4220.748
19	Said Haboob	5260.006	852.686	5071.787
20	AlBasri	6517.728	2141.456	2905.778
Max.		**13671.729**	**2874.604**	**5147.327**
Min.		**3212.938**	**312.755**	**1496.168**
Ave.		**7827.009**	**1239.918**	**1594.323**

Table 4.9 Internal hazard indices (H_{in}) for samples of soil and grain (rice and wheat) in Al- Shamiyah city.

No.	**Location**	**H_{in}**		
		Soil	**Rice**	**Wheat**
1	AlJoboor	0.168	0.019	0.055
2	Abo Kofoof	0.118	0.004	0.036
3	AlHadadi	0.133	0.023	0.049
4	Tabar AlZaweed	0.099	0.007	0.027
5	AlFilahi	0.156	0.015	0.034
6	AlChalakh	0.128	0.017	0.033
7	AlNajaria	0.077	0.005	0.019
8	AlGiratia	0.115	0.015	0.021
9	AlHafar	0.088	0.002	0.019
10	Nodaiba	0.097	0.008	0.026
11	AlAin	0.144	0.021	0.037
12	AlOshr	0.064	0.009	0.021
13	AlGataa	0.101	0.009	0.028
14	AlSada	0.115	0.022	0.031
15	Om AlWard	0.079	0.009	0.036
16	AlKhashania	0.148	0.026	0.049
17	Abo Gorban	0.075	0.009	0.015
18	AlHassan	0.112	0.023	0.049

19	Said Haboob	0.081	0.006	0.049
20	AlBasri	0.096	0.019	0.033
Max.		**0.168**	**0.026**	**0.055**
Min.		**0.064**	**0.004**	**0.015**
Ave.		**0.109**	**0.013**	**0.033**
Worldwide[2]		**≤1**	**≤1**	**≤1**

Table 4.10 External hazard indices (H_{ex}) for samples of soil and grain (rice and wheat) in AlShamiyah city.

No.	**Location**	**H_{ex}**		
		Soil	**Rice**	**Wheat**
1	AlJoboor	0.126	0.017	0.036
2	Abo Kofoof	0.101	0.004	0.021
3	AlHadadi	0.105	0.013	0.029
4	Tabar AlZaweed	0.081	0.005	0.019
5	AlFilahi	0.118	0.013	0.024
6	AlChalakh	0.107	0.013	0.025
7	AlNajaria	0.069	0.005	0.016
8	AlGiratia	0.101	0.013	0.018
9	AlHafar	0.071	0.002	0.015
10	Nodaiba	0.091	0.007	0.022
11	AlAin	0.102	0.011	0.026
12	AlOshr	0.058	0.008	0.011
13	AlGataa	0.079	0.006	0.019
14	AlSada	0.089	0.013	0.021
15	Om AlWard	0.072	0.006	0.026
16	AlKhashania	0.107	0.016	0.031
17	Abo Gorban	0.059	0.005	0.009
18	AlHassan	0.094	0.017	0.036
19	Said Haboob	0.071	0.006	0.033
20	AlBasri	0.074	0.011	0.022
Max.		**0.126**	**0.017**	**0.036**
Min.		**0.058**	**0.002**	**0.009**
Ave.		**0.089**	**0.009**	**0.023**
Worldwide[2]		**≤1**	**≤1**	**≤1**

An annual ingestion dose ($\mu Sv.y^{-1}$) estimation was done for the grin(rice and wheat) collected from Al-Shamiyah city. From the annual consumption rate, the annual ingestion dose was determined [127]. The results of the grain (rice and wheat) collected from Al-Shamiyah city are presented in Tables 4.11 and 4.12 respectively. The larger total ingestion dose was determined for ^{238}U, ^{232}Th and ^{40}K in rice were found 35.730 μ Sv.y $^{-1}$ in Al-Khashania and the lower was 3.780 (μSv y $^{-1}$) in Al-Giratia with average 17.666 respectively. The larger total ingestion dose was determined for ^{238}U, ^{232}Th and ^{40}K in wheat were found was 209.450 μSv.y $^{-1}$ in Al-Joboor and the lower were 60.216 μSv.y $^{-1}$ in Abo Gorban with average131.601 respectively. From these results found the annual ingestion dose from wheat is larger than from rice because then human is eating quantity of wheat larger than rice (Ministry of Trading).

Table 4.11 Ingestion dose (E_{ING})for samples of rice in Al-Shamiyah city.

No.	Location	E_{ING} (μ Sv. y $^{-1}$)			Total
		^{238}U	^{232}Th	^{40}K	
1	AlJoboor	3.692	1.342	16.415	21.450
2	Abo Kofoof	0.434	4.217	2.123	6.774
3	AlHadadi	25.195	2.108	3.071	30.374
4	Tabar AlZaweed	3.258	0.767	4.097	8.122
5	AlFilahi	4.561	1.725	11.081	17.367
6	AlChalakh	6.51٦	0.958	12.643	20.117
7	AlNajaria	0.217	5.367	2.114	7.698
8	AlGiratia	3.91	5.942	9.704	19.555
9	AlHafar	1.738	1.533	0.509	3.780
10	Nodaiba	2.389	8.05	2.641	13.080
11	AlAin	24.977	1.917	0.877	27.771
12	AlOshr	5.4299	5.75	3.211	14.391
13	AlGataa	9.122	0.383	2.422	11.927
14	AlSada	23.24	0.192	4.685	28.117
15	Om AlWard	8.0362	2.492	2.211	12.739
16	AlKhashania	27.367	4.6	3.764	35.730
17	Abo Gorban	9.774	0.575	1.649	11.998
18	AlHassan	15.204	3.258	10.27	28.736
19	Said Haboob	0.652	7.475	2.343	10.469
20	AlBasri	23.457	1.15	0.9388	25.546
Max		**27.367**	**7.475**	**16.415**	**35.730**
Min		**0.217**	**0.192**	**0.509**	**3.780**

Ave	9.958	2.99	4.718	17.666

Table 4.12 Ingestion Dose (E_{ING}) for samples of wheat in AlShamiyah city.

No.	Location	E_{ING} (μ Sv y $^{-1}$)			Total
		^{238}U	^{232}Th	^{40}K	
1	AlJoboor	151.167	6.325	51.957	209.450
2	Abo Kofoof	121.195	16.1	9.344	146.638
3	AlHadadi	156.38	21.275	19.635	197.290
4	Tabar AlZaweed	60.597	13.225	30.743	104.565
5	AlFilahi	74.932	15.525	39.850	130.307
6	AlChalakh	62.552	7.475	51.325	121.353
7	AlNajaria	26.063	28.75	27.979	82.792
8	AlGiratia	20.199	20.125	41.297	81.621
9	AlHafar	31.276	26.45	23.347	81.073
10	Nodaiba	32.579	40.825	37.2439	110.648
11	AlAin	89.267	21.85	35.612	146.729
12	AlOshr	29.973	23	31.216	84.189
13	AlGataa	65.158	3.45	35.902	104.510
14	AlSada	81.448	5.75	30.374	117.572
15	Om AlWard	76.887	12.075	46.325	135.286
16	AlKhashania	147.91	22.425	29.005	199.340
17	Abo Gorban	46.262	6.9	7.054	60.216
18	AlHassan	96.434	32.775	62.196	191.405
19	Said Haboob	123.149	39.675	37.533	200.358
20	AlBasri	83.403	9.775	33.481	126.658
Max		**156.38**	**40.825**	**62.196**	**209.450**
Min		**20.199**	**3.45**	**7.054**	**60.216**
Ave		**78.842**	**18.688**	**34.071**	**131.601**

4.4 Transfer factor for radionuclides

The transfer factor determines how many radionuclides are absorbed by grain (rice and wheat) from the soil (TF). It is known as the proportion between the concentrations of radionuclide in grain to concentrations of radionuclide in soil [2]. To calculate TF in this study used equation 2.1. The results are showed in Tables 4.13 and 4.14. For the rice the maximum transfer factor of 0.202 in Al-Joboor and the lowest was 0.018 in Al-Basri with average 0.069, the highest TF of 0.399 in Al-Basri and the lowest was 0.009 in Abo Kofoof with mean value 0.179 and the highest TF of 0.355 in Al-Hassan and the lowest was 0.077in Al-Joboor with mean value 0.185 for ^{238}U, ^{232}Th and ^{40}K respectively.

Table 4.14 refers to the wheat exhibited the highest TF of. 0.703 in Om Al-Ward and the lowest was 0.181 in Al-Giratia with average 0.556, the highest TF of 0.894in Al-Ain and the lowest was 0.076 in Al-Gataa with mean value 0.424 and the highest TF of 0.283 in Al-Hassan and the lowest was 0.044 Abo Kofoof with mean value 0.196 for ^{238}U, ^{232}Th and ^{40}K respectively. Generally, the transfer factor For ^{238}U, ^{232}Th and ^{40}K in order: wheat > rice > . Absorbed the radioactivity nuclides which have a same an essential nutrient, it has a chemical behavior. Following that, radionuclides were transferred to particular tissues based on the element's role in grain metabolism. If there is an increase in soil concentrations, grain concentrations rise in good cases. A linear relationship means that the ratio of grain to soil concentration is constant. [128].

Table 4.13 Transfer Factor for natural radioactivity samples of from soil to rice in AlShamiyah city

No.	Location	T.F.(^{238}U)	T.F.(^{232}Th)	T.F.(^{40}K)
1	AlJoboor	0.032829899	0.076923077	0.201900244
2	Abo Kofoof	0.009538702	0.113921218	0.029861907
3	AlHadadi	0.024936437	0.09662751	0.04264169
4	Tabar AlZaweed	0.06718727	0.071759259	0.067021055
5	AlFilahi	0.044646636	0.087248322	0.14651926
6	AlChalakh	0.114949829	0.131968146	0.143083767
7	AlNajaria	0.010816469	0.187880545	0.040455417
8	AlGiratia	0.10464444	0.140344019	0.133640114
9	AlHafar	0.038783392	0.057921102	0.011218588
10	Nodaiba	0.132587859	0.166638094	0.040517634
11	AlAin	0.035790151	0.293519695	0.014360237
12	AlOshr	0.320441989	0.666026871	0.063235113
13	AlGataa	0.062262997	0.025484765	0.044587741
14	AlSada	0.049238743	0.043233083	0.069942489
15	Om AlWard	0.101837061	0.254868755	0.033990893
16	AlKhashania	0.049107724	0.142967344	0.069529256
17	Abo Gorban	0.007779469	0.157175399	0.037061559

18	AlHassan	0.010075935	0.221099888	0.140136212
19	Said Haboob	0.026007431	0.354673998	0.042299275
20	AlBasri	0.048195719	0.214506173	0.017604587
Max		0.320441989	0.666026871	0.201900244
Min		0.007779469	0.025484765	0.011218588
Ave		0.064582908	0.175239363	0.069480352

Table 4.14 Transfer Factor for natural radioactivity from samples of soil to wheat in AlShamiyah city

No.	Location	T.F.(^{238}U)	T.F.(^{232}Th)	T.F.(^{40}K)
1	AlJoboor	0.03999744	0.121082621	0.213012911
2	Abo Kofoof	0.166536357	0.145031334	0.043804328
3	AlHadadi	0.052024252	0.32436529	0.090887113
4	Tabar AlZaweed	0.413290113	0.410493827	0.167623832
5	AlFilahi	0.244674848	0.26216443	0.175639542
6	AlChalakh	0.367839451	0.342434585	0.193625228
7	AlNajaria	0.421144452	0.335459553	0.178447124
8	AlGiratia	0.180188861	0.158522283	0.189586061
9	AlHafar	0.233022208	0.333437696	0.171631101
10	Nodaiba	0.602236422	0.281844677	0.190469179
11	AlAin	0.266044416	1.116899619	0.19428513
12	AlOshr	0.589885253	0.888675624	0.20490427
13	AlGataa	0.369051988	0.07700831	0.220353611
14	AlSada	0.407191448	0.434210526	0.151147215
15	Om AlWard	1.421325879	0.411515665	0.237387237
16	AlKhashania	0.015044939	0.232193366	0.178608095
17	Abo Gorban	0.362252664	0.633257403	0.052841186
18	AlHassan	0.040595794	0.740179574	0.282790242
19	Said Haboob	0.251214633	0.627258445	0.225917223
20	AlBasri	0.472293578	0.608024691	0.209283636
Max		1.421325879	1.116899619	0.282790242
Min		0.03999744	0.07700831	0.043804328
Ave		0.344266757	0.418442647	0.178612213

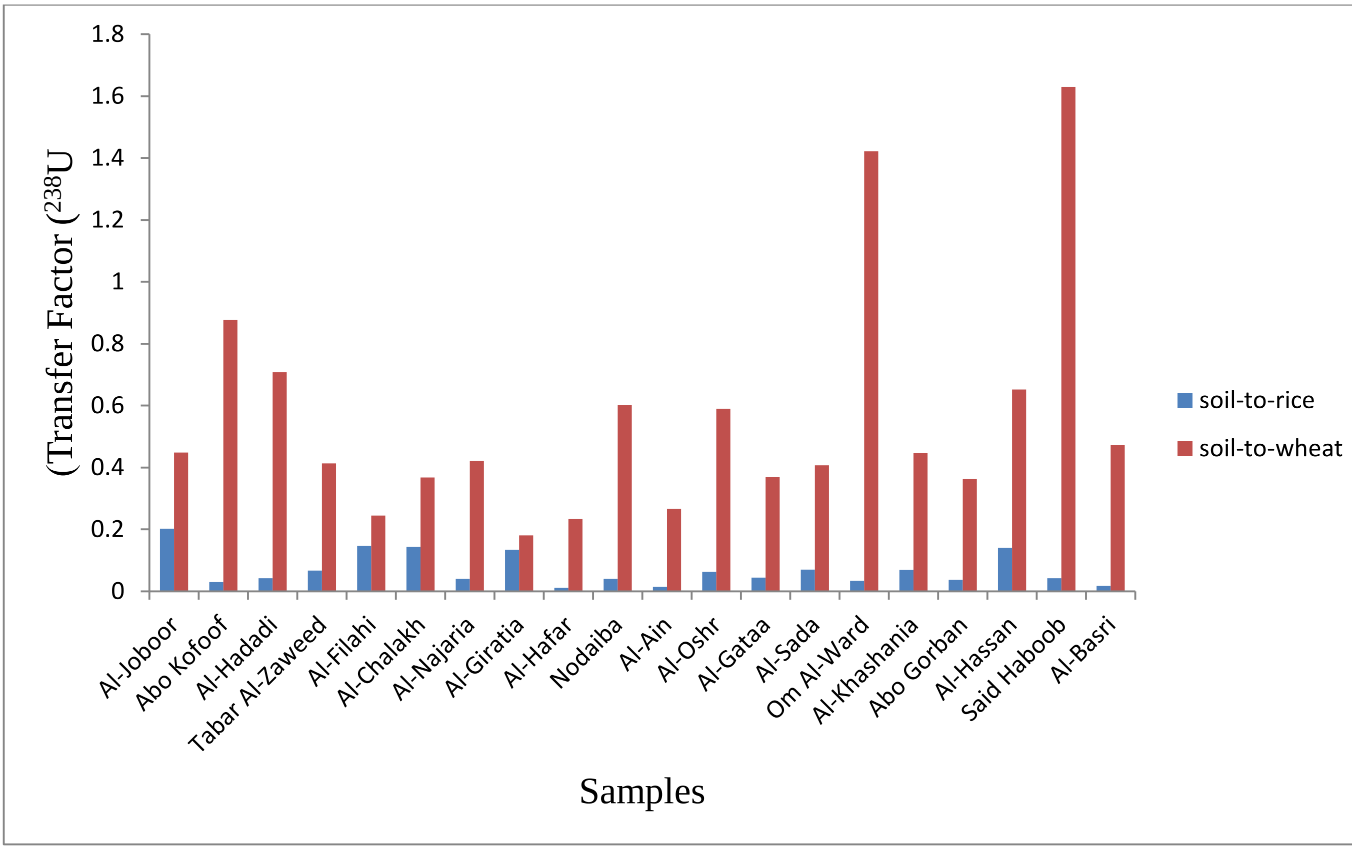

Figure 4.4 Transfer Factor for ^{238}U from samples of soil to grain (rice and wheat) in AlShamiyah city

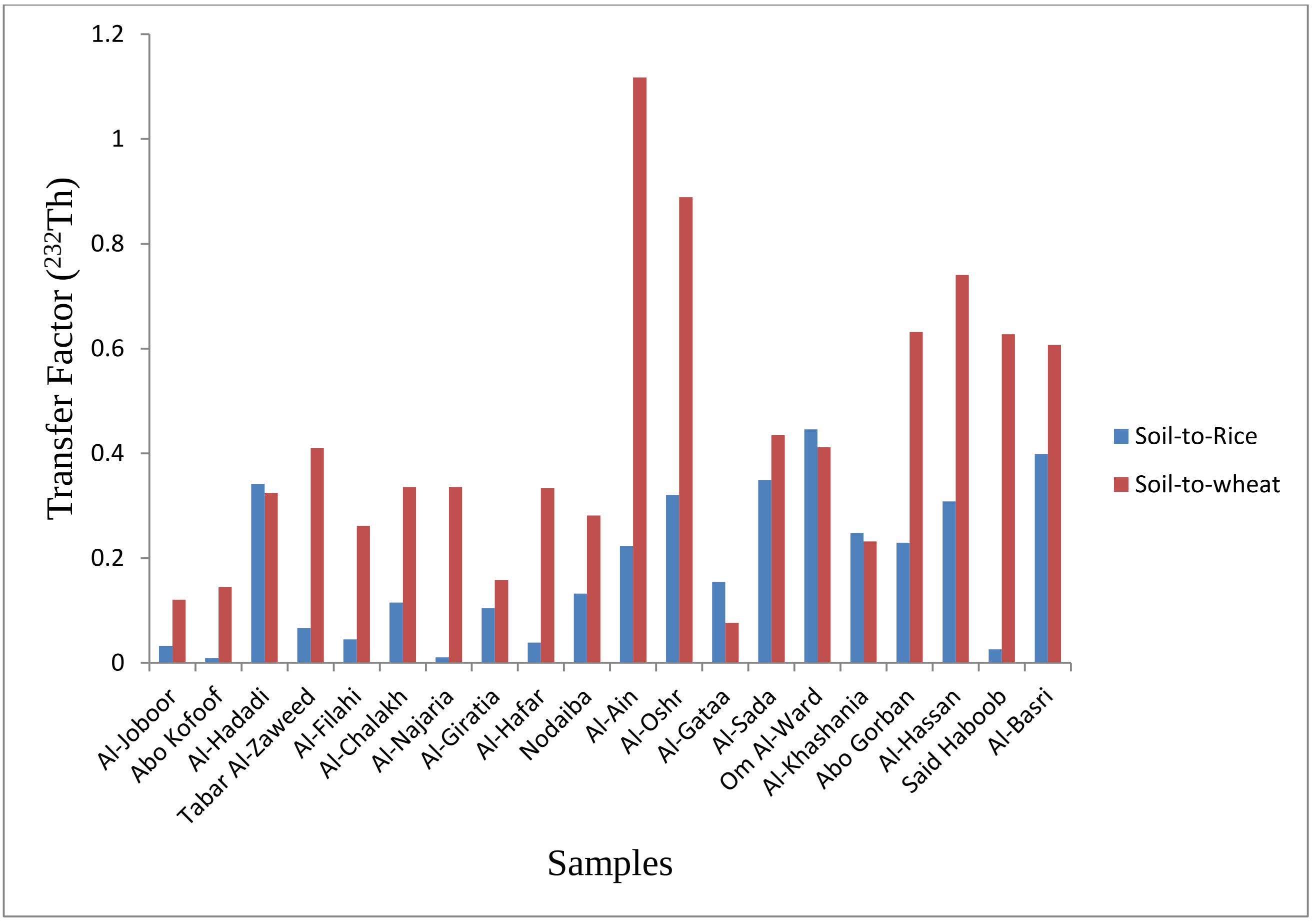

Figure 4.5 Transfer Factor for ^{232}Th from samples of soil to grain (rice and wheat) in AlShamiyah city

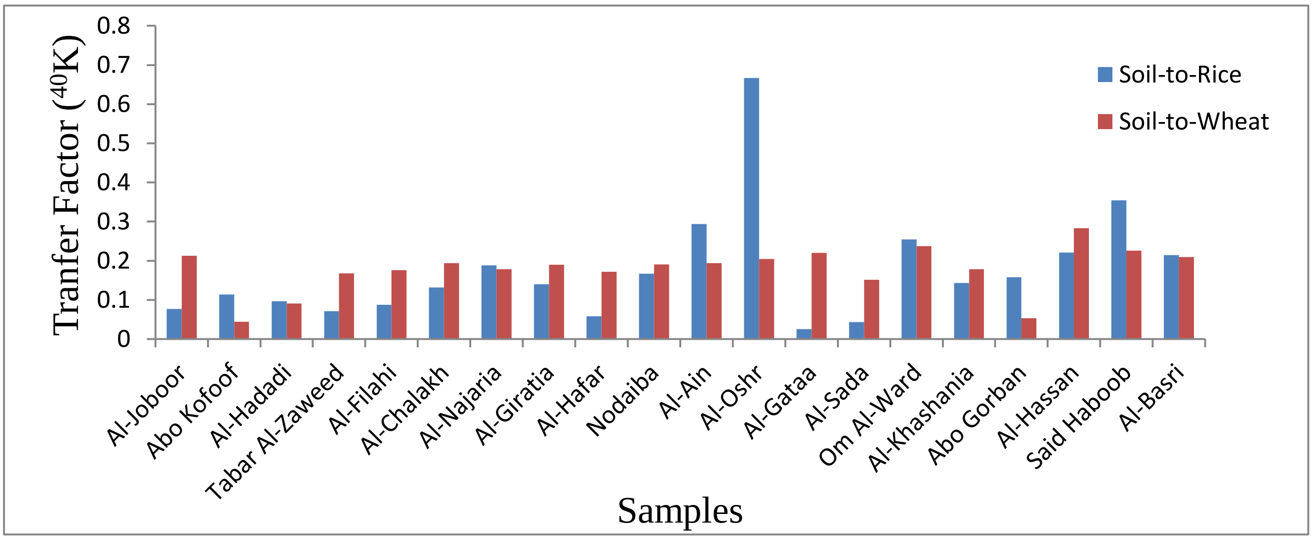

Figure 4.6 Transfer Factor for $^{40}K$from samples of soil to grain (rice and wheat) samples in AlShamiyah city

Table 4.15 Comparison between factor of transfer of radiological nuclide from soil to grain (rice and wheat)obtain in present study and them in other studies.

Country	Grain	^{238}U	^{232}Th	^{40}K	Ref.
Japan	Brown rice	$5.6*10^{-5}$	$1.0*10^{-5}$	$2.2*10^{-1}$	[129]
Japan	Wight rice	$1.1*10^{-4}$	$1.3*10^{-4}$	$6.2*10^{-2}$	
South West India	Not mentioned	$8.8*10^{-2}$	$14.2*10^{-2}$	$6.3*10^{--1}$	[130]
West Coast India	Un-hulled rice	-	-	1.5	[131]
Penang Malaysia	Hulled rice	$1.8*10^{-2}$	$2.2*10^{-5}$	$1.8*10^{-2}$-$7.8*10^{-2}$	[126]
Al- Shamiyah city	Rice	0.069	0.179	0.185	Present Work
	Wheat	0.556	0.424	0.196	
IAEA reported value	Combined data for brown and white rice	$2.2* 10^{-4}$ -$2.8* 10^{-2}$	$3.0* 10^{-2}$	-	[132]

4.5 Concentration of Uranium

By using CR-39 detector and source of neutrons , uranium concentration were determined in samples of soil and grain (rice and wheat) Tables 4.16, 4.17, and 4.18 indicate concentrations of uranium in samples of soil and grain (wheat and rice) in Al-Shamiyah agriculture, which were determined using a CR-39 detector and recorded in parts per million (ppm) on a mass basis. Results showed that the maximum uranium was 2.064±0.081ppm in AlChalakh and the min. Activity was 0.3640.001ppm in AlAin, with a rate of 1.119±0.016ppm for soil. In the case of rice, the greatest uranium content was 0.0260±005 ppm in Al-Gataa. In AlHafar, however, the lowest activity is 0.0020±001 ppm, with an average value of 0.0930±002 ppm. On the other side of the wheat, Al-Oshr had the greatest uranium content at 0.021±0.005 ppm, whereas

Tabar Al-Zaweed had the lowest at 0.004±0.001 ppm wheat had an average uranium content of 0.011±0.001 ppm. The findings show that the uranium concentrations in the study samples varied substantially depending on the type of uranium material. The samples were discovered to be in the following order: soil > wheat > rice. According to the IAEA, uranium uptake by plants is influenced by a variety of soil parameters such asclay concentration, textur, exchangeabl caption, dominating clay minerals, organic matter concentration, environmental and p H factors. A current findings are calculated in Table 4.19 for comparison with findings from other nations. By comparing the data, it was discovered that the soil concentration in Iraq is lower than in Brazil, the Check, India, Kuwait, and Baghdad and Al-Basra

Table 4.16 Uranium concentration of in samples of soil samples from Al-Shamiyah city

No.	location	Concentration of Uranium(ppm)					Mean
		1	2	3	4	5	
1	AlJoboor	1.992	1.893	1.814	1.728	1.882	1.858±0.021
2	Abo Kofoof	0.993	0.989	0.908	0.931	0.956	0.951±0.012
3	AlHadadi	1.481	1.422	1.414	1.429	1.477	1.441±0.017
4	Tabar AlZaweed	0.567	0.583	0.538	0.551	0.556	0.554±0.002
5	AlFilahi	2.118	2.027	2.059	2.171	1.979	2.064±0.081
6	AlChalakh	0.328	0.319	0.244	0.282	0.332	0.292±0.001
7	AlNajaria	0.421	0.466	0.416	0.447	0.491	0.444±0.004
8	AlGiratia	1.113	1.181	1.192	1.193	1.148	1.144±0.011
9	AlHafar	1.682	1.559	1.757	1.682	1.783	1.688±0.013
10	Nodaiba	0.364	0.336	0.387	0.372	0.382	0.364±0.001
11	AlAin	1.393	1.446	1.371	1.338	1.392	1.384±0.014
12	AlOshr	1.513	1.544	1.552	1.537	1.555	1.536±0.013
13	AlGataa	1.125	1.077	1.139	1.181	1.114	1.122±0.011
14	AlSada	1.653	1.548	1.667	1.633	1.594	1.614±0.012
15	Om AlWard	0.866	0.912	0.814	0.825	0.891	0.858±0.001
16	AlKhashania	0.667	0.717	0.773	0.771	0.793	0.738±0.002
17	Abo Gorban	2.028	2.122	1.981	2.127	2.072	2.062±0.214
18	AlHassan	0.724	0.649	0.617	0.681	0.617	0.652±0.002

19	Said Haboob	1.091	1.033	1.049	1.077	1.074	1.061±0.016
20	AlBasri	0.591	0.563	0.534	0.595	0.513	0.556±0.001
Max							**2.064±0.081**
Min							**0.364±0.001**
Ave							**1.119±0.016**
Worldwide[2]							**11.7**

Table 4.17 Concentration of uranium in rice samples from AlShamiyah city

No.	**location**	**Concentration of Uranium(ppm)**					**Mean**
		1	**2**	**3**	**4**	**5**	
1	AlJoboor	0.002	0.003	0.003	0.004	0.004	0.003±0.001
2	Abo Kofoof	0.007	0.006	0.007	0.006	0.006	0.006±0.002
3	AlHadadi	0.007	0.009	0.009	0.008	0.008	0.008±0.002
4	Tabar AlZaweed	0.005	0.005	0.004	0.004	0.005	0.005±0.001
5	AlFilahi	0.009	0.008	0.007	0.008	0.007	0.008±0.003
6	AlChalakh	0.007	0.007	0.007	0.007	0.007	0.007±0.002
7	AlNajaria	0.017	0.018	0.019	0.019	0.018	0.018±0.007
8	AlGiratia	0.008	0.008	0.009	0.009	0.009	0.009±0.003
9	AlHafar	0.003	0.002	0.001	0.003	0.001	0.002±0.001
10	Nodaiba	0.007	0.007	0.008	0.007	0.007	0.007±0.002
11	AlAin	0.008	0.008	0.009	0.008	0.009	0.008±0.003
12	AlOshr	0.005	0.005	0.005	0.005	0.005	0.005±0.001
13	AlGataa	0.012	0.13	0.014	0.14	0.013	0.026±0.005
14	AlSada	0.017	0.015	0.015	0.016	0.017	0.016±0.003
15	Om AlWard	0.011	0.012	0.015	0.012	0.012	0.012±0.003
16	AlKhashania	0.003	0.004	0.005	0.004	0.003	0.004±0.001
17	Abo Gorban	0.012	0.001	0.015	0.011	0.011	0.011±0.003
18	AlHassan	0.006	0.007	0.007	0.006	0.005	0.006±0.002
19	Said Haboob	0.012	0.014	0.15	0.012	0.013	0.014±0.003
20	AlBasri	0.016	0.016	0.015	0.019	0.017	0.017±0.004
Max							**0.026±0.005**
Min							**0.002±0.001**
Ave							**0.093±0.002**

Table 4.18 Concentration of uranium in samples of wheat from AlShamiyah city

No.	**location**	**Concentration of Uranium(ppm)**					**Mean**
		1	**2**	**3**	**4**	**5**	
1	AlJoboor	0.006	0.006	0.007	0.006	0.007	0.006±0.002
2	Abo Kofoof	0.016	0.016	0.016	0.015	0.016	0.016±0.004

3	AlHadadi	0.007	0.007	0.007	0.007	0.007	0.007±0.002
4	Tabar AlZaweed	0.004	0.003	0.005	0.004	0.005	0.004±0.001
5	AlFilahi	0.01	0.011	0.009	0.012	0.009	0.011±0.003
6	AlChalakh	0.011	0.013	0.011	0.012	0.011	0.012±0.003
7	AlNajaria	0.011	0.011	0.011	0.012	0.01	0.011±0.003
8	AlGiratia	0.006	0.007	0.006	0.007	0.006	0.006±0.002
9	AlHafar	0.008	0.009	0.009	0.007	0.007	0.008±0.002
10	Nodaiba	0.008	0.007	0.008	0.008	0.007	0.008±0.002
11	AlAin	0.017	0.017	0.018	0.018	0.017	0.017±0.004
12	AlOshr	0.019	0.023	0.019	0.022	0.021	0.021±0.005
13	AlGataa	0.015	0.013	0.014	0.014	0.013	0.014±0.003
14	AlSada	0.013	0.011	0.012	0.013	0.013	0.012±0.003
15	Om AlWard	0.014	0.015	0.014	0.013	0.014	0.014±0.003
16	AlKhashania	0.009	0.01	0.01	0.009	0.009	0.009±0.002
17	Abo Gorban	0.017	0.017	0.017	0.018	0.018	0.011±0.003
18	AlHassan	0.009	0.008	0.008	0.009	0.007	0.008±0.002
19	Said Haboob	0.018	0.018	0.018	0.016	0.016	0.017±0.004
20	AlBasri	0.009	0.011	0.01	0.009	0.011	0.011±0.003
Max							**0.021±0.005**
Min							**0.004±0.001**
Ave							**0.011±0.001**

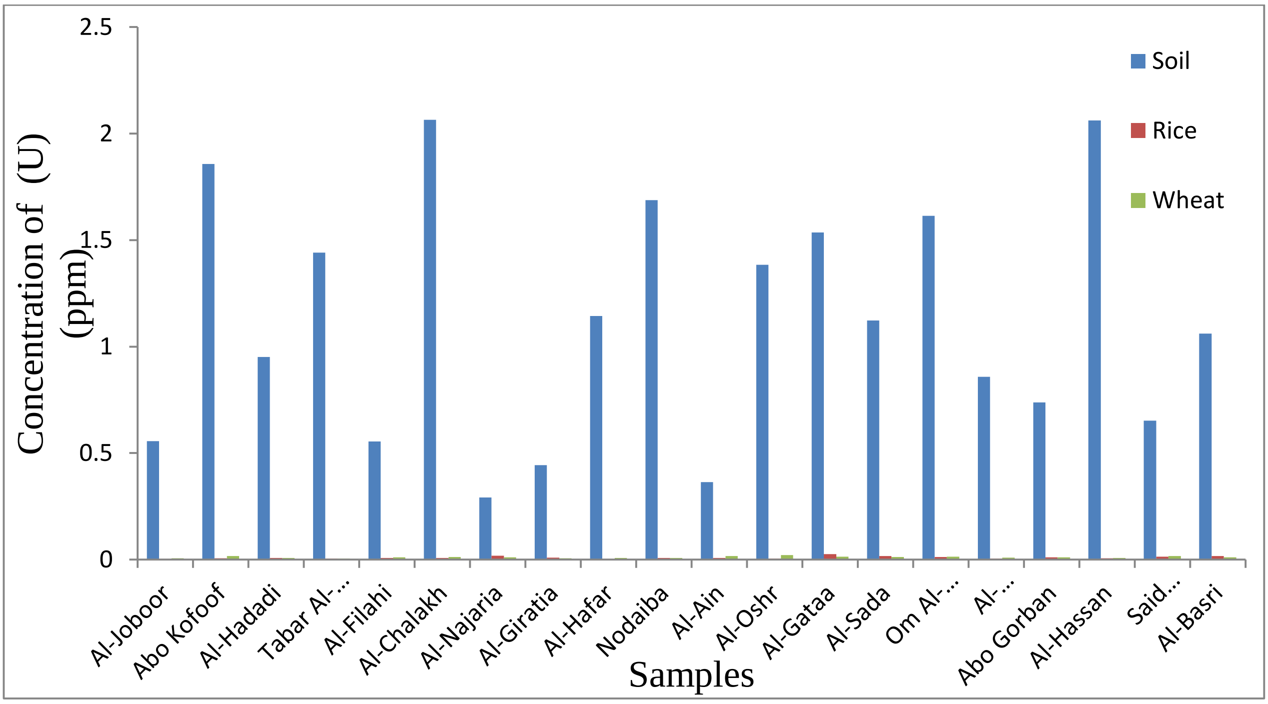

Figure 4.7 Concentration of uranium in samples of soil and grain (rice and wheat) from Al-Shamiyah city

Table 4.19 Comparison between concentration of uranium nuclide in soil obtain in present study and them in other studies.

Nation	Uranium con. (ppm) for Soil	References
Barazil	0.001-2.12	[133]
Chechk	2 - 4	[134]
India	0.24 -9.2	[135]
Kowait	0.3 – 1.9	[136]
Earth Crust	2.50	[2]
Baghdad City	3.82	[137]
AlBasra (Q0rna)	16.1	
Al- Shamiyah city	**1.119±0.016**	**Present Work**
UNSCEAR	**11.7**	**[2]**

4.6 Concentration of Radon

Radon levels were detected in farming soil and grain (rice and wheat) samples from Al- Shamiyah, a town noted for its agricultural grains, particularly rice and wheat. The calculated radon concentration levels are summarized in Tables 4.20, 4.21 and 4.22. Al-Sada has the highest radon levels in the soil, it was119.593±5.361 $Bq.m^{-3}$. The lowest radon concentration of was 3.698±0.003$Bq.m^{-3}$ was found in Said Haboob, with an average of 49.879±2.241$Bq.m^{-3}$. In the case of rice, the greatest radon concentration was 11.583±1.051$Bq.m^{-3}$ in Abo Kofoof. The lowest concentration, on the other hand, was 2.097±0.001$Bq.m^{-3}$in Al-Basri, with a mean value 7.012±0.937 $Bq.m^{-3}$. From the other hand the wheat, the greatest radon concentration was 13.414±0.071$Bq.m^{-3}$in Al-Haffar. In addition that lowest concentration is 1.625±0.001$Bq.m^{-3}$in Al-Khashania concentration of radon for wheat is 8.425±0.012 B.m^{-3}. Mean concentration of radon is less than the recommended values of (200 Bq.m^{-3}) for the planet[2]. All of the findings were compared to those of other research around the world, and the current study revealed that In Barazil, Egypit, India, Lebya, and Pakestan, radon levels are lower. Table 4.23 shows the results. Because of changes in geological natural of the soil, the activity differed from nation to nation, according to the findings.

Table 4.20 Concentration of Radon in samples of soil from AlShamiyah city

No.	location	Concentration of Radon(Bq.m^{-3})					Mean
		1	2	3	4	5	
1	AlJoboor	97.592	85.264	86.292	79.101	74.992	84.648 ±3.813
2	Abo Kofoof	31.846	36.982	20.546	27.737	29.791	29.381±1.951
3	AlHadadi	19.518	18.491	15.409	20.546	14.382	17.669±1.028
4	Tabar AlZaweed	25.682	26.709	23.628	22.601	29.791	25.682±2.401
5	AlFilahi	34.928	38.009	36.982	36.009	35.955	36.377±2.927
6	AlChalakh	38.009	34.928	32.678	33.783	37.904	35.461±1.938
7	AlNajaria	76.019	77.046	79.101	70.883	77.129	76.036±3.769
8	AlGiratia	80.128	83.289	85.265	83.718	88.119	84.104±4.016
9	AlHafar	72.937	70.883	77.192	74.296	73.884	73.838±2.715
10	Nodaiba	25.682	21.573	22.601	27.195	24.694	24.349±1.182
11	AlAin	81.155	83.615	80.593	87.148	84.178	83.338±3.972
12	AlOshr	15.409	16.094	14.382	18.491	17.903	16.456±1.009
13	AlGataa	45.201	42.119	48.282	44.826	47.009	45.487±2.127
14	AlSada	121.894	110.947	108.892	115.056	141.178	119.593±5.36
15	Om AlWard	67.801	63.692	65.746	66.774	63.692	65.541±2.174
16	AlKhashania	23.628	20.546	23.628	26.709	24.232	23.748±1.875
17	Abo Gorban	52.957	54.501	55.473	50.337	50.399	52.733±2.283
18	AlHassan	56.501	52.392	51.364	57.528	58.555	55.268±2.884
19	Said Haboob	3.081	8.218	4.216	2.055	1.027	3.698±0.003
20	AlBasri	43.146	47.255	41.091	45.201	44.173	44.173±1.973
Max							**119.593±5.36**
Min							**3.698±0.003**
Ave							**49.879±2.241**
Worldwide[2]							**200**

Table 4.21 Radon concentration for samples of rice from AlShamiyah city

No.	location	Concentration of Radon(Bq.m^{-3})					Mean
		1	2	3	4	5	
1	AlJoboor	6.629	6.862	6.164	6.861	6.719	6.647±0.427
2	Abo Kofoof	11.746	12.676	10.816	11.979	10.699	11.583±1.051
3	AlHadadi	8.257	9.303	8.373	8.489	9.421	8.769±0.937
4	Tabar AlZaweed	5.815	5.815	5.466	5.349	5.931	5.676±1.002
5	AlFilahi	3.605	4.536	4.768	4.187	4.419	4.303±0.005
6	AlChalakh	10.467	11.979	10.234	10.001	10.849	10.706±1.019
7	AlNajaria	2.907	2.941	2.784	2.668	2.285	2.717±0.024
8	AlGiratia	6.745	6.396	6.861	6.396	6.629	6.606±0.936
9	AlHafar	5.815	5.349	5.931	5.466	5.001	5.512±0.918
10	Nodaiba	7.792	7.559	7.327	7.211	7.327	7.443±1.092
11	AlAin	8.722	8.141	8.422	8.503	8.404	8.438±1.101
12	AlOshr	3.721	4.303	4.536	4.6519	4.071	4.256±0.036
13	AlGataa	7.443	7.094	7.211	7.908	7.739	7.479±0.965
14	AlSada	9.536	9.614	9.942	9.282	9.347	9.5441±1.017
15	Om AlWard	5.233	5.582	5.698	5.679	5.284	5.495±0.802
16	AlKhashania	11.397	11.509	10.917	12.017	11.191	11.406±1.203
17	Abo Gorban	4.768	4.536	4.303	4.486	4.617	4.542±0.005
18	AlHassan	9.071	9.536	9.769	9.421	5.233	8.606±1.017
19	Said Haboob	8.839	8.606	8.257	8.373	8.024	8.419±0.903
20	AlBasri	1.994	2.404	1.592	2.601	1.893	2.097±0.001
Max							**11.583±1.051**
Min							**2.097±0.001**
Ave							**7.012±0.937**

Table 4.22 Radon concentration for samples of wheat from AlShamiyah city

No.	location	Concentration of Radon(Bq.m-^{3})					Mean
		1	2	3	4	5	
1	AlJoboor	8.606	8.257	8.417	8.373	8.562	8.443±0.011
2	Abo Kofoof	5.117	5.699	5.001	5.815	5.278	5.382±0.002
3	AlHadadi	10.118	10.234	10.467	11.048	10.729	10.519±0.015
4	Tabar AlZaweed	3.838	3.992	3.728	3.109	3.821	3.698±0.002
5	AlFilahi	6.978	6.047	6.513	6.629	6.625	6.558±0.004

6	AlChalakh	7.443	7.676	7.559	7.719	7.691	7.617±0.004
7	AlNajaria	9.421	8.189	9.653	9.304	9.372	9.187±0.016
8	AlGiratia	8.838	8.955	9.304	9.187	9.163	9.089±0.013
9	AlHafar	12.327	11.746	17.793	13.173	12.027	13.414±0.071
10	Nodaiba	3.024	3.838	3.605	3.191	3.392	3.411±0.001
11	AlAin	4.419	4.536	4.187	4.303	4.768	4.443±0.002
12	AlOshr	10.351	9.769	9.719	9.916	10.183	9.988±0.014
13	AlGataa	8.722	8.024	8.711	8.582	8.955	8.599±0.011
14	AlSada	5.815	5.931	5.028	5.572	5.652	5.599±0.003
15	Om AlWard	6.745	6.629	6.047	6.351	6.396	6.434±0.007
16	AlKhashania	1.489	1.802	1.192	1.711	1.932	1.625±0.001
17	Abo Gorban	4.884	5.132	4.7682	4.077	4.395	4.651±0.002
18	AlHassan	5.117	5.274	5.233	5.816	5.569	5.402±0.002
19	Said Haboob	10.001	9.187	10.816	9.423	9.938	9.873±0.007
20	AlBasri	7.443	7.908	7.709	7.559	7.713	7.666±0.005
Max							**13.414±0.0715**
Min							**1.625±0.001**
Ave							**8.425±0.012**

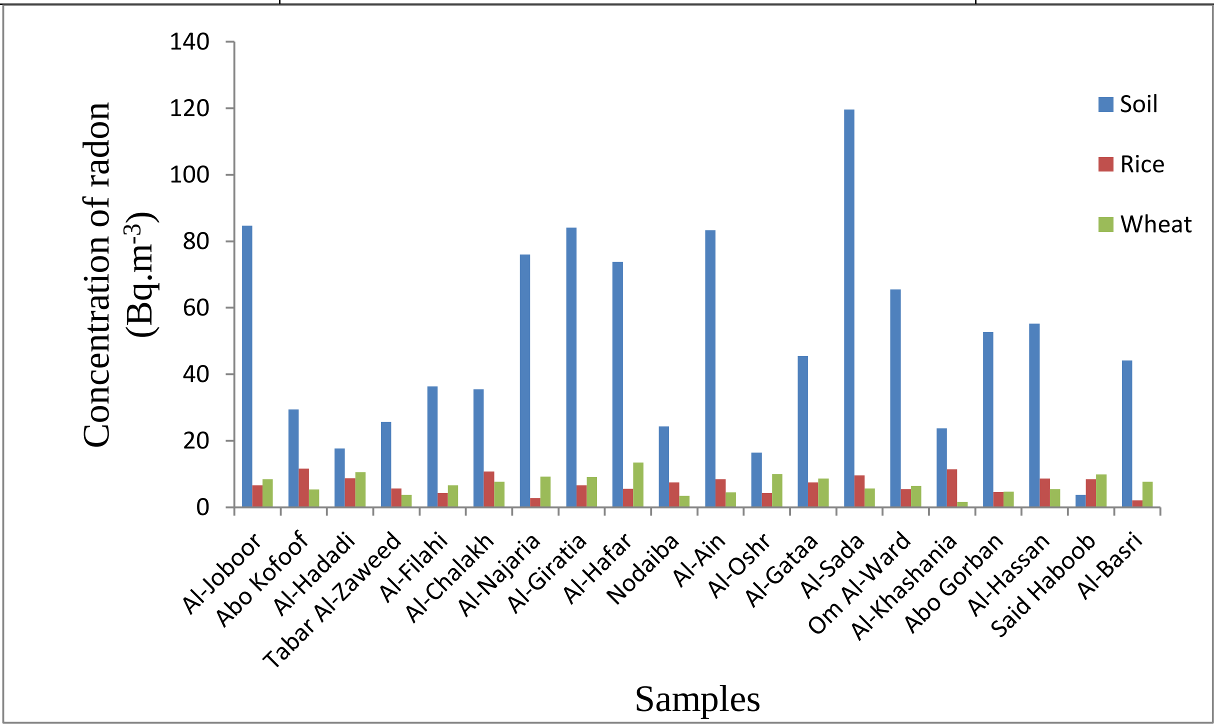

Figure 4.8 radon concentration for samples of soil and grain (rice and wheat) from Al-Shamiayh city

Table 4.23 Comparison between concentration of uranium radionuclide in soil obtain in present study and them in other studies.

Country	C_{Rn} (Bq.m^{-3})			Ref.
	Min.	Max.	Mean	
Brazil	4	404	69	[138]
Egypt	3130	6970	5110	[139]
India	177.5	583.4	330.5	[140]
Libya (Benghazi)	31.1	469	220.3	[141]
Libya (Al-Marj)	59.3	515.8	325.5	
Pakestan	-	-	261.67	[142]
Al- Shamiyah city	0.12	13.02	6.48	Present Work
UNSCEAR			**200**	**[2]**

4.7 Transfer Factor for Uranium

In this study, factor of transfer for grain (wheat and rice) samples were also determined. The results are reported in Table 4.24 and Figure 4.10, respectively, with factor of transfer for uranium between soil and rice values ranging from (0.002and 0.063). as well as factor of transfer for uranium from soil to wheat, about (0.003and0.026). The TF for U from soil to grain varies according to soils, grain, and location. Rice and wheat uptake of isotope for soil is influenced by a number of factors, including texture, exchange capacity, exchangeable captions, pH, content and minerals of clay, dominating and organic matter concentration. It change based on the radionuclides' chemical and physical properties, plant type, and growth stage.

Table 4.24 Factor of transfer of uranium from soil to grain (rice and whaet) in AlShamiayh city

No.	Location	Transfer Factor	
		Soil→Rice	Soil→Wheat
1	AlJoboor	0.006	0.012
2	Abo Kofoof	0.003	0.009
3	AlHadadi	0.009	0.007
4	Tabar AlZaweed	0.003	0.003
5	AlFilahi	0.014	0.018
6	AlChalakh	0.003	0.006
7	AlNajaria	0.062	0.038
8	AlGiratia	0.019	0.014
9	AlHafar	0.002	0.007
10	Nodaiba	0.004	0.005
11	AlAin	0.023	0.048
12	AlOshr	0.004	0.015
13	AlGataa	0.041	0.009
14	AlSada	0.014	0.011
15	Om AlWard	0.008	0.009
16	AlKhashania	0.004	0.011
17	Abo Gorban	0.014	0.014
18	AlHassan	0.003	0.041
19	Said Haboob	0.063	0.026
20	AlBasri	0.016	0.009
Max		**0.063**	**0.026**
Min		**0.002**	**0.003**
Ave		**0.0157**	**0.0156**

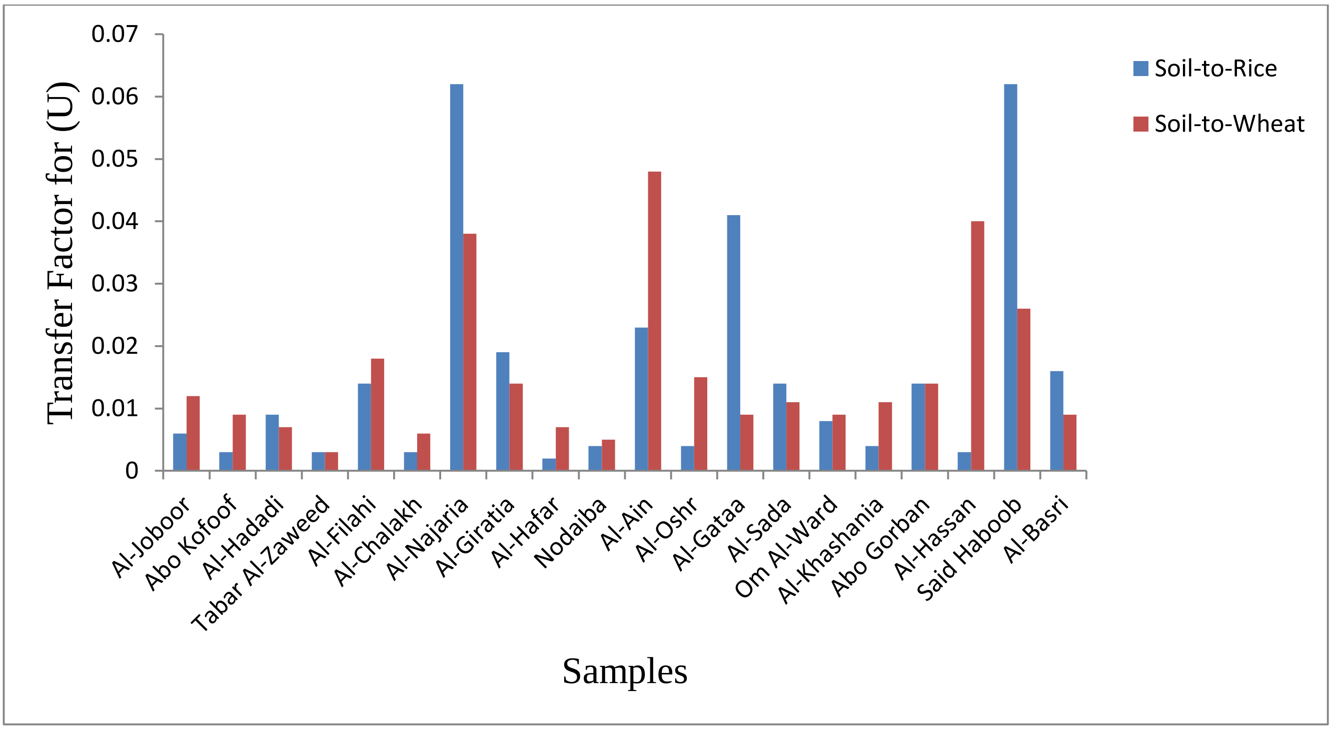

Figure 4.9 Factor of transfer of uranium from soil to grain (rice and wheat) in AlShamiyah city

Chapter Five

Conclusions, Future Work and Recommendations

5.1 Conclusions

From this studying we can find:

1. The study of natural radioactivity levels of uranium-238, thorium-232 and potassium-40 as well as radon-222 and uranium in agricultural soil and grain (rice and wheat) samples has provided baseline data in the areas of study. However, these data can be a good background for the regions under study which can play a major role in mapping of radio activity for Iraq.

2. The natural radionuclides of ^{238}U, ^{232}Th and ^{40}K have been measured in samples of soil collected from AlShamiyah, Al-Qadisiya in Iraq, these according to the findings, the highest activity for ^{238}U, ^{232}Th and ^{40}K. The results were consistent with those found from other investigations. ^{238}U concentration of is lesser than the concentration recorded in Jordon and Taiwan and. On the other side, the ^{238}U and ^{232}Th concentration are lesser than the values recorded in India ,Thailand and Kazakhstan. The ^{40}Kconcentration is higher than the values recorded in Thailand, Egypt and Iraq in (Al-Najaf, Al-Basrah

3.The natural radioactivity of ^{238}U, ^{232}Th and ^{40}K has been measured in grain (rice and wheat) samples collected from AlShamiyah, Al-Qadisiyia in Iraq. These figures are consistent with those found in other investigations. as shown in table 4.14. Furthermore, the radiological hazards for dirt and grain(rice and wheat) sample obtained in Al-Shamiyah, Al-Qadisiyia Iraq such as activity of radium equivalent and internal and external hazard indices are lesser than the values recorded [2].

4. For groups of grain obtained from AlShamiyah city, AlQadisiyia governorate in Iraq, the annual ingestion dose was calculated. The total ingestion doses of ^{238}U, ^{232}Th and ^{40}K in rice and wheat were the recommended values. The type of natural radioactivity, crop, and soil parameters all influence radionuclide absorption from soil to grain (rice and wheat). Generally, of transfer of soil to grain (rice and wheat) collected arranged of ^{40}K > ^{232}Th> ^{238}U. In order to type of grain: the factor of transfer soil-to-wheat > soil-to-rice .

5. For samples obtained in AlShamiyah, Iraq, uranium in concentrations soil, crops (wheat and rice), and TF for S →G (wheat and rice) were calculated. According to current studies, uranium concentrations in soil vary depending on the kind of soil, location, and geological shape of area for the work.

6. The findings of this work, however, demonstrate that grain consumption is beneficial. does not pose any severe health risks to humans. Because the max. concentration of uranium in the environment was unsuitable, continual observing of U concentration in soil, crops ,and transfer factor between soil and grain should be carried out

7. All results of the uranium transfer factor show that the transfer factor between soil and wheat is greater from it between soil to rice, possibly because of the time frame for and quantity of water and fertilizers utilized in the agriculture.

8. The concentrationof radon was measured in agricultural soil and grain (rice and wheat) samples were taken in AlShamiyah, Al-Qadisiyah,

which is known for its grain production, especially rice and wheat. The concentration's averaged values of radon in soil ,rice and wheat are below the world mean value.

9. When the findings were compared to those of other studies around the world, it was discovered that the current study's radon concentrations were lower than that of other countries

5.2 Future Work

The natural radioactivity analysis in environmental media's ultimate goal is to provide baseline evidence. The following research may be done in the future:

1. Studying of the natural radioactivity levels in other regions such as Mishkhab and Al-Sanyah. There are many studies done in Babylon Al-Diwaniyah, Karbala and Al-Basra thus more studies need to be done in other regions of Iraq.
2. Studying the natural radioactivity present samples by using HPGe compare the results with the NaI(Tl) detector.
3. Determination of radon and thoron concentrations in soil, air and groundwater by different kinds of detector (CN-85, LR-115) and compare the results with the CR-39 detector.
4. Radon concentration is critical since it accounts for more than half of the dose. As a result, further research into indoor radon exposure is needed.
5. Use CR-39 to investigate the normal radioactivity and radon levels in fertilizer storage warehouses. Determination of concentrations of radon and concentrations of thoron in soil, air and groundwater by different kinds of detector (CN-85, LR-115) and compare the results with the CR-39 detector.

6. . Studying ingestion dose of animals from the consumption of grain (rice and wheat) and measuring the concentrations of natural radioactivity in the meat and milk.

5.3 Recommendations

1. To competent authorities such as the ministry of agriculture, the ministry of health and the ministry of the environment, the local government and the geological survey. In order to preserve the environment and public health of radiation risks the radioactivity and radon gases, hazardous to a human health when their concentrations are increasing permitted levels which causes lung cancer. Therefore, it is necessary to measure concentrations continuously, during year seasons as done in the developed countries such as Britain.

2. We shall recommend to repeat such study for all governors of Iraq.

3. Because the count of the track method is not accuracy suggests using other active continuous techniques such as (Alpha Guard, Scintillation Cell) to determine the radon and thoron concentration in water, soil and grain.

CHAPTER ONE

GENERAL INTRODUCTION

CHAPTER TWO

THEORETICAL PART

CHAPTER THREE

EXPERMENTAL PART

CHAPTER FOUR

RESULTS AND DESCASSION

CHAPTER FIVE

CONCULUSIONS, FUTURE WORK AND RECOMMENDATIONS

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