زانكۆی سەلاحەدین - هەولێر
Salahaddin University-Erbil

An Overview of:

Natural Radioactive Nuclides In Wheat Grain

Research project

Submitted To The Department Of (PHYSICS) In Partial Fulfillment Of The Requirements For The Degree Of B.Sc. In (PHYSICS).

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بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

"لَقَدْ كُنْتَ فِي غَفْلَةٍ مِنْ هَذَا فَكَشَفْنَا عَنْكَ غِطَاءَكَ فَبَصَرُكَ الْيَوْمَ حَدِيدٌ"

سورة ق، آية ﴿٢٢﴾

This project is dedicated:

- To My Parents
- To My Brother and Sisters
- To My Friends
- For Their Constant Support and Encouragement.

Sawen

Acknowledgement

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Abstract

Natural background radiation is the main source of human exposure to radioactive material. Soils naturally have radioactive mineral contents. This study aims to survey the results of natural (^{238}U, ^{232}Th, ^{40}K) radioactivity levels in the wheat grain in some countries. Generally, the HPGe detector was used to measure the concentration activity of ^{238}U and ^{232}Th series, as well as ^{40}K in wheat samples. Transfer factors (TFs) of long-lived radionuclides such as ^{226}Ra, ^{232}Th , and ^{40}K from soils to wheat plants have been studied.

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Chapter One

Introduction

1.1: Introduction

Humans and other organisms in their environment are under continuous radiation of natural radioactive material found in the earth's crust and cosmic rays. In addition, they receive radiation of medical and industrial sources. The most important natural radionuclides are ^{226}Ra, ^{40}K, ^{232}Th which with the different physical and chemical properties enter into the physical and biological environments ($Bahari\ I,\ 2007$). ^{226}Ra with half-life 1620 years belong to ^{238}U chain is one of the main pollutants in the natural radiation environment and there is widely in different ecosystems. Higher solubility of this element than uranium causes this element be washed by underground water and brought to the surface. This element is chemically similar to calcium and absorbed by plants through the soil and then through the food chain enters human's body. Almost 70% of ^{226}Ra is accumulated in the bones and the rest spread to soft tissues of the body. This radionuclide is a bone-oriented element and due to its long half-life remains in bones. However because of alpha radiation serious dangers such as bone marrow cancer can threat human health. Average annual absorption of ^{226}Ra through the food and drink is about 19 Bq in global level that causes effective dose equivalent approximately 3.8 μSv in a year ($Jibiri\ NN,\ 2007$).

The main stages of infection entering the human food chains are:

1. To be untaken radionuclide by plants through leaves or roots and transferring it to fruit or in cereal and legumes to grains.
2. Radionuclide transport from plants, fodder animals and animal products.

3. Finally human in biological cycle, both through the polluted plants and animal products can be affected.

Therefore it is necessary to pay attention to radioactivity pollution and their mechanism absorption. Amount of radioactive pollution in various food and plants according to their absorption capacity is different. Consumed diet, consumed dosage, preparation site, and ways of preparing food, whether vegetable or animal influence on the effects that plant pollution can put on people. Considering that the main objective of the study of radioactive contamination in plant sources is the impact on humans, makes necessary to do this type of studies ($TahirSN,$ 2005). Also, the use of phosphate fertilizers in agricultural land makes multiplier radionuclide levels in soil and eventually plant contamination ($Abdel - Rassoul\ AA,$ 2007).

Many worldwide studies show that food can absorb radioactive materials. Wheat is of important grains which are grown in different regions of the world. Eilam Province in Iran is including areas that these grains as their main products are planted. People of Eilam consume wheat for their food. Wheat grows in any soil, but the soil quality can increase the exact product per unit area. So that the silt clay and silt soils that composed of fluvial sediments give the best product. Soils with silt clay loam texture, silt loam, silt clay (with the requirement of having cubic structure) and the loam are suitable for wheat ($Habrurema\ E,$ 1997).

Determination of radionuclide concentrations in wheat and to determine the effective dose from radionuclide according to the annual consumption of wheat in different areas of the province has a special place. Since it is possible that radionuclide values existed in wheat to be excessive and endanger safety of people living in the area it was decided to do a study on this issue so the amount and type of radionuclide were determined in Eilam Province. In addition to determine the concentration of natural and artificial radioactive materials, the amount of transferring them from soil to plant was determined and compared.

1.2 Source of radiation

Radiation is everywhere. Most occurs naturally, but a small percentage is human-made. Naturally occurring radiation is known as background radiation.

1.2.1 Background Radiation

Many materials are naturally radioactive. In fact, this naturally occurring radiation is the major source of radiation in the environment. Although people have little control over the amount of background radiation to which they are exposed, this exposure must be put into perspective. Background radiation remains relatively constant over time; background radiation present in the environment today is much the same as it was hundreds of years ago Sources of background radiation include uranium in the earth, radon in the air, and potassium in food. Background radiation is categorized as space, terrestrial, or internal, depending on its origin.

1.2.2 Cosmic radiation

Energetically charged particles from outer space continuously hit the earth's atmosphere. These particles and the secondary particles and photons they create are called space or cosmic radiation. Because the atmosphere provides some shielding against space radiation, the intensity of this radiation increases with altitude above sea level. For example, a person in Denver, Colorado, is exposed to more space radiation than a person in Death Valley, California

1.2.3 Terrestrial radiation

refers to radiation emitted from radioactive materials in the earth's rocks, soils, and minerals. Radon (Rn); radon progeny, the relatively short-lived decay products of radium-226 (226Ra); potassium (40K); isotopes of thorium (Th); and isotopes of uranium (U) are the elements responsible for most terrestrial radiation.

1.3 Internal radiation

Radioactive material in the environment can enter the body through different routes of exposure, for example, the air people breathe and the food they eat; or through an open wound. Natural radionuclides that can enter the body include isotopes of uranium, thorium, radium, radon, polonium, bismuth, and lead in the ^{238}U and ^{232}Th decay series. Inaddition, the body contains isotopes of potassium (^{40}K), rubidium (^{87}Rb), and carbon (^{14}C).

1.4 Human-made Radiation

Most people are exposed to human-made sources of radiation. Examples include consumer products, medical sources, and industrial or occupational sources. About one-half of 1% of the U.S. population performs work in which radiation in some form is present. Atmospheric testing of atomic weapons was a source of human-made radiation, but testing has been suspended in the United States and most parts of the world. Fallout from atmospheric weapons testing is not currently a significant contributor to background radiation (Health Physics Society 2010).

1.5 Pathways Of Radiation:

Radiation and radioactive materials in the environment can reach people through many routes (see Figure R.3). Potential routes for radiation are referred to as pathways. For example, radioactive material in the air could fall on a pasture. The grass could then be eaten by cows, and the radioactive material on the grass would be present in the cow's milk. People drinking the milk would thus be exposed to this radiation. Or people could simply inhale the radioactive material in the air. The same events could occur with radioactive material in water. Fish living in the water would be exposed; people eating the fish would then be exposed to the radiation in the fish. Or people swimming in the water would be exposed.

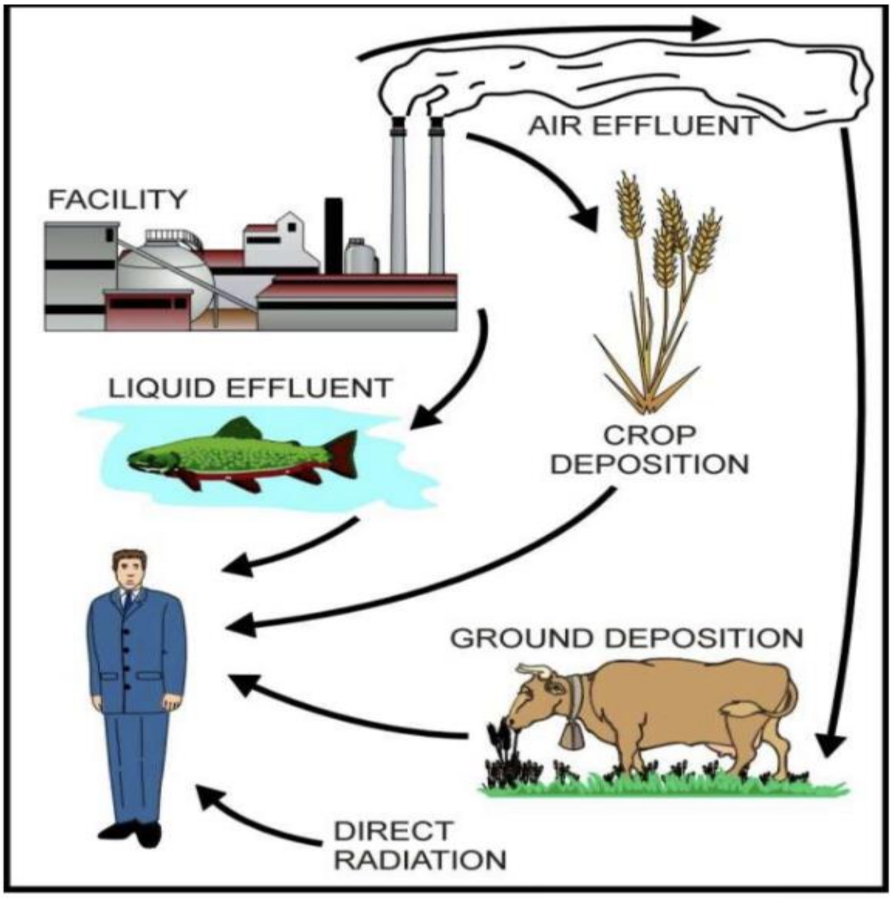

Figure R.3. Possible radiation pathways.

Chapter Two
Material and Methods

2.1: Preparation of samples

For samples soil particles, stems of wheat and their skins were removed carefully. Wet sample's weight (not dried) was measured by the balance. Samples were dried against the sun for 2 days.

Then the samples were ground by the conventional grinding mill, and finally passed through a 1 mm mesh to get homogeneous samples to be entered within Marineli. Samples. Soils were screened to be taken large rocks, roots and stems of plants out. Then they were dried against sunlight by the action of natural aeration for 4 to 5 days. For complete drying samples were placed in the oven for 48 hours at a temperature of 200 ° C. To get homogeneity in Marineli container the samples weight was selected of about 950 ±0.01 gr. Marineli containers were sealed for 30 days to prevent releasing radon gas out of the sample and the longstanding balance creation between ^{226}Ra and ^{222}Ra and its decay products in the ^{238}U series and also between ^{228}Ra and its products in the ^{232}Th.

2.2: Spectroscopy and analysis of samples

To determine the activity and concentration of natural and artificial radionuclides each sample was placed in gamma radiation spectrometer system (HPGe) with efficiency of 38.5% and energy resolution of 920 ev at energy of 122kev. Concentration of radioactive substances in samples was compared with the international standards.

Following calibration of detection system performance and determining the minimum detectable activity of system, quantitative analysis of prepared samples was performed. Photo peak efficiency for each of the peaks with the mentioned energy can be calculated using the following equation:

$$\boldsymbol{\varepsilon}\,(\%) = \frac{\boldsymbol{Net\ Area}}{\left(\boldsymbol{Act.}_{(\boldsymbol{Bq})}\right) * \left(\boldsymbol{B.R}_{(\%)}\right) * \left(\boldsymbol{t}_{(\boldsymbol{Sec.})}\right)} * \mathbf{100}$$

In this equation, $\boldsymbol{\varepsilon}$ is the detector efficiency, $Act.$ Is a radionuclide activity existed in standard sample in terms of Bq, $B.R$ shows breakaway energy related to desired energy in terms of percentage, t reveals the spectroscopy time duration of the sample and Net Area is area under the requested peaks.

To determine the average concentration of ^{226}Ra, the activity of ^{214}Pb with peaks at energies of 295.22 (kev) and 351.93 (kev) and ^{214}Bi with peak at energy of 609.31 (kev) were used. Also for 228Ra, ^{228}Ac with peaks at energies of 911.2 (kev), 968.97 (kev) and 338.32 (kev) was taken.

In this study AKAWIN software was used for spectrometry. The activity of samples was collected in the ranges of 40000–80000 sec and 20000–40000 sec to get reasonable statistics for wheat and soil respectively.

2.3: Radioactive detectors:

For detecting gamma ray spectrometers used **scintillation counter** and **HPGe**

2.3.1:Scintillation Counter:

A scintillation Counter is an instrument that is used for measuring ionizing radiation. “It comprises the scintillator that generates photons in response to incident radiation”, a PMT tube is used to convert an electronics and electric signal to process the signal. is used to detect gamma rays and the presence of a particle

2.3.2: High Purity Germanium (HPGe) Radiation Detectors:

HPGe detector refers to High Purity (HP) Germanium (Ge) semiconductor detector to detect gamma ray lines emitted by radionuclides. It is mostly used in gamma ray spectrometry work since it gives highly resolved energy peaks. This makes it possible to identify ppb levels of radionuclides present in the unknown sample

Chapter Three

Discussion and Conclusions

3.2 Discussion

Natural radioactivity levels in samples of wheat were evaluated in Eilam Province (Iran). Natural radioactivity in the areas of Eilamwas found very low and almost in the level of global standards. Tables 3.1 – 3.3 reveal comparison of mean concentrations of ^{226}Ra, ^{232}Th, and ^{40}K in wheat samples among some studies in world including present work. According to these tables ^{226}Ra and ^{232} The level for wheat in Eilam Province is greater than those in France and Kazakhstan but smaller than iraq. ^{40}K level for wheat in Eilam Province was lower than that in France iraq(Erbil) and Kazakhstan.

Importance of pollution varies with the growing season, so area before harvest, during harvest, or under active grazing by domestic animals (such as animals that produce milk) would be at more risk. Wheat's cluster structure makes easy to attract and capture radionuclides. As in winter the products are not on the ground, risk is kept at the lowest level. Of course, it is possible that natural radio-nuclides to be saved on the ground in permanent pastures in winter and to be absorbed by the growing plants next spring. This recording and maintenance for plants that their body parts such as old stems or surface roots are exposed will be more. Generally, direct contamination is to be considered less than contamination by soil, because the determining factors of it have more diversity. Soils used for wheat cultivation is clay loam soil.

The radium concentrations for wheat samples were under allowable levels and therefore there's no the risk of ionizing radiation effects on humans. It is necessary to consider that allowable level of radium-226, according to the international standard values is defined as 110 m Bq/ liter ($BrownJE, 2004$).

One of the reasons for increasing radionuclides in vegetables can be use of fertilizers such as phosphate fertilizer. However, the amount of radioactive elements for wheat and corn in Eilamprovince was so low that consumer health is not to be threatened. Radionuclides are being absorbed through the roots and leaves of plants. The values in the tables 5, 6, 7, 8 show that radioactive substances were being absorbed by plants through roots of wheat and corn. However absorption of radioactive material in grain area of crop was less than the others (root, stem). This study showed the transfer of radioactive materials into plant's seed area was to be very low.

Table 3.1: Comparison of mean concentrations of ^{226}Ra in wheat samples among some studies.

Country	Sample	Ra-226(Bq/kg)	References
France	Wheat	0.570±0.057	*Akhtar N*, 2005
Kazakhstan	Wheat	1.100±0.176	*Akhtar N*, 2005
Iraq(Erbil)	Wheat	0.89± 0.15	Hiwa H. Azeez
Total wheat samples	wheat	1.67±0.12	

Table 3.2: Comparison of mean concentrations of ^{232}Th in wheat samples among some studies.

Country	Sample	(Bq/kg) Th^{232}	References
France	Wheat	<0.035	*Akhtar N*, 2005
Kazakhstan	Wheat	<0.035	*Akhtar N*, 2005
Iraq(Erbil)	Wheat	<0.28	Hiwa H. Azeez
Total wheat samples	wheat	0.50	

Table 3.3: Comparison of mean concentrations of ^{40}K in wheat samples among some studies.

Country	**Sample**	**^{40}K(Bq/kg)**	**References**
France	Wheat	146.3±7.3	*Akhtar N*, 2005
Kazakhstan	Wheat	99.4±2.0	*Akhtar N*, 2005
Iraq(Erbil)	Wheat	201.96± 7.53	Hiwa H. Azeez
Total wheat samples	Wheat	91.73±0.45	

3.2 Transition factor

Transfer of radioactive elements from soil to plant is determined by transition factor (TF). This factor include radionuclide concentration per gram of plant (dry or wet plant weight) (Bq/g) at harvest divided by radionuclide concentration per gram of soil (Bq /g). TF is dependent on the factors such as, radionuclide type, product type, soil type, EC, pH and bicarbonate content of the soil. Using TF we can find if plants receive contamination from soil or root. Finally, the absorbed doses of these elements can be estimated in humans. In this study transfer rate of according to the following transfer factor equation in the samples of corn and wheat based on strategic role of products has been calculated.

TF = Radionuclide concentration in plant (dry weight) (Bq / g) / Radionuclide concentrations in soil (Bq / g) (dry weight)

Transfer factor for the ^{232}Th in most samples of wheat and corn was zero. Since the ^{232}Th is a synthetic element, its presence in plants can be dangerous. ^{232}Th sticks tightly to clay mineral soil that is available for plant. Its root uptake is low, but the leaf absorption, especially when the nuclear loss is ongoing would be important. Thorium and potassium are double. Thorium absorption rate is inversely proportional to soil's potassium. Experience has shown that Thorium ransport through root uptake is low enough to be ignored. The main method of reducing pollution is washing plants, peeling fruits and seeds like wheat.

^{232}Th accumulation in plants that grow in top mountain areas, such as mosses and lichens, is more than that of those grow in the protected are-as. Potassium move and spread more easily within the plant so that the direct absorption of the surface led to widespread contamination in other parts. Move and transfer coefficients for major agricultural seeds are in the range of 3- 29 that according to the type of seed, this difference could appear to be 45 times (*Abu-Khadra SA, 2008*) Tables 5–8 reveal transition rate of ^{40}K, ^{226}Ra, ^{232}Th from soil to plant for wheat and corn samples.

Table 3.4: Transition rate of ^{40}K from soil to plant for wheat and corn samples.

	Cp	Cs	TF=Cp/Cs (K40)
SA	94.56	190.05	0.49
SB	50.57	219.50	0.23
SC	92.35	188.13	0.49
SD	114.47	187.13	0.61
SE	91.46	153.23	0.59
SF	157.66	261.46	0.60
SG	78.61	267.46	0.29
SH	42.99	71.66	0.59
SI	114.04	108.52	1.05
SJ	47.99	192.16	0.24
SK	107.21	195.20	0.54

	Cp	Cs	TF=Cp/Cs (K40)
SL	126.78	318.13	0.39

Table 3.5:Transition rate of ^{226}Ra from soil to plant for wheat and corn samples.

	Cp	Cs	TF=Cp/Cs (Ra226)
SA	0.08	46.77	0.001
SB	0.16	29.53	0.005
SC	0.72	17.95	0.04
SD	0.17	17.89	0.009
SE	0.08	27.67	0.002
SF	0.61	25.39	0.02
SG	3.93	25.40	0.15
SH	0.09	16.55	0.005
SI	0.80	20.36	0.03
SJ	0.29	26.08	0.011
SK	0.72	25.67	0.02
SL	0.53	30.09	0.017

Table 3.6:Transition rate of ^{232}Th from soil to plant for wheat and corn samples.

	Cp	Cs	TF=Cp/Cs (^{232}Th)
SA	0	15.78	**0**
SB	0.33	16.75	0.01
SC	1	12.64	0.07
SD	1.08	12.67	0.08
SE	0	12.3	0
SF	1.14	17.26	0.06
SG	0.98	17.78	0.05
SH	0.16	13.40	0.01
SI	0	7.65	0
SJ	0.55	15.14	0.03
SK	1.02	16.78	0.06
SL	1.06	12.76	0.08

3.3 Conclusion

Studies worldwide have reported varying concentrations of radium, thorium, and potassium isotopes in wheat grain, influenced by factors such as soil composition, agricultural practices, and environmental conditions. Comparisons with other food products and environmental matrices have revealed the unique radioactivity profiles of wheat grain, highlighting its significance as a dietary source of natural radionuclides.

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تێڕوانینێکی گشتی بۆ:

(گەردیلە تیشکدەرە سروشتییەکان لە دانەوێڵەی گەنمدا)

پرۆژەی دەرچوونە

پێشکەش بە بەشی (فیزیا) کراوە، وەک بەشێک لە پێداویستیەکانی بە دەستهێنانی بڕوانامەی بەکالۆریۆس لە زانستی (مێژوو)

ئامادەکراوە لە لایەن:

ساوین عبدالرحمن عبدالله

بەسەرپەرشتی :

یاریدەدەری پرۆفیسۆر دکتۆر: هیوا حەمەد عزیز

نیسان- ٢٠٢٤

زانكۆی سەلاحەدین - هەولێر
Salahaddin University-Erbil

نظرة عامة على:

(نوى النشاط الإشعاعي الطبيعي في حبوب القمح)

مشروع تخرج

مقدمة الى قسم (الفيزياء) كجزء من متطلبات نيل درجة بكالوريوس في (فيزياء)

اعداد

ساوين عبالرحمن عبدالله

بأشراف

أستاذ مساعد دكتور : هيوا حمد عزيز

ابريل-٢٠٢٤