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Transfer of natural radionuclides from soil to some commonly daily used vegetables in Erbil governorate

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SUPERVISOR CERTIFICATE

This thesis has been written under my supervision and has been submitted for the award of the degree of BSc. in Nuclear Physics with my approval as supervisor.

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Abstract

Radioactivity in Food may be contaminated with radioactive materials due to the natural and a nuclear emergency. The vegetables and fruits will become radioactive due to transfer of radionuclides from soil to vegetables. The aims of the present work were to measure the specific activity activities of primordial radionuclides in some common vegetables and transfer factor (TF) in in soil to vegetables. In this study, the activities of ^{238} U, ^{232}Th, and ^{40}K were successfully measured via gamma-ray spectrometry , to determine the specific activity of ^{238}U ^{232}Th and ^{40}K in essential vegetable samples collected from farms of Qasre in Choman. The specific activity of natural radionuclides was measured in soil ,chemical fertilizer ,pepper ,celery , Radish and head Radish .The results show that the highest specific activity of ^{238}U was found in celery(13.3 Bq/kg) while the minimum in pepper(0.88 Bq/kg). For ^{232}Th the maximum activity was found in celery (2.78 Bq/kg) and minimum in raddish leaves (1.09 Bq/kg). finally the maximum specific activity of ^{40}K was found in celery (2642.85 Bq/kg) and the minimum was detected in pepper (1595.79 Bq/kg).

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Chapter one

Introduction:-

1-1Radioactivity:-

Radioactivity is the term used to describe the natural process by which some atoms spontaneously disintegrate, emitting both particles and energy as they transform into different, more stable atoms. This process, also called radioactive decay, occurs because unstable isotopes tend to transform into a more stable state. Radioactivity is measured in terms of disintegrations, or decays, per unit time. Common units of radioactivity are the Becquerel, equal to 1 decay per second, and the Curie, equal to 37 billion decays per second.Radiation refers to the particles or energy released during radioactive decay [Gilmore, 2011]. The radiation emitted may be in the form of particles, such as neutrons, alpha particles, and beta particles, or waves of pure energy, such as gamma and X-rays.Each radioactive element, or radionuclide, has a characteristic half-life. Half-life is a measure of the time it takes for one half of the atoms of a particular radionuclide to disintegrate (or decay) into another nuclear form. Half-lives vary from millionths of a second to billions of years. Because radioactivity is a measure of the rate at which a radionuclide decays (for example, decays per second), the longer the half-life of a radionuclide, the less radioactive it is for a given mass.Everyone is exposed to radiation on a daily basis, primarily from naturally occurring cosmic rays, radioactive elements in the soil, and radioactive elements incorporated in the body. Man-made sources of radiation, such as medical X-rays or fallout from historical nuclear weapons testing, also contribute, but to a lesser extent. About 80% of background radiation originates from naturally occurring sources, with the remaining 20% resulting from man-made sources (Argon 2013). Due to nuclear instability, an atom's nucleus exhibits the phenomenon of Radioactivity. Energy is lost due to radiation that is emitted out of the unstable nucleus of an atom. Two forces, namely the force of repulsion that is electrostatic and the powerful forces of attraction of the nucleus, keep the nucleus together. These two forces are considered extremely strong in the natural environment. The chance of encountering instability increases as the size of the nucleus increases because the mass of the nucleus becomes a lot when concentrated. That's the reason why atoms of Plutonium, Uranium are extremely unstable and undergo the phenomenon of radioactivity.Henry Becquerel discovered radioactivity by accident. A Uranium compound was placed in a drawer containing photographic plates, wrapped in a black paper [Reus and Westmeier 1983].

1-2Radioactive Decay:-

Radioactivity is the phenomenon exhibited by an atom's nuclei due to nuclear instability. In 1896, Henry Becquerel discovered this phenomenon. Radioactivity is a process by which the nucleus of an unstable atom loses energy by emitting radiation. A small amount of Uranium compound was wrapped in black paper and put in a drawer containing photographic plates. These plates were later examined, and the results revealed that there had been an exposure. Radioactive Decay is the term introduced for this phenomenon. The elements or isotopes that emit radiation and go through radioactivity are known as radioactive elements. Learn more about the radioactive decay law in this article [Morino, Ohara and Nishizawa, 2011]

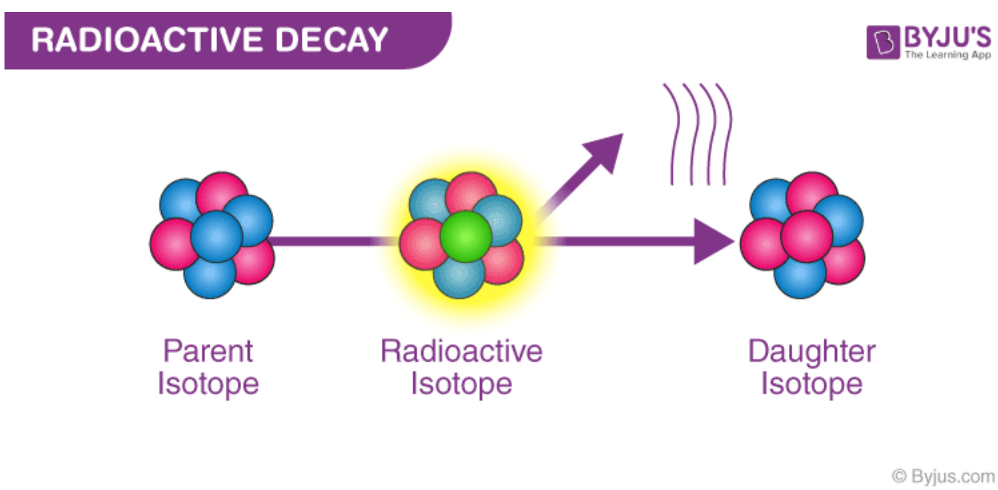

Figure 1. Radioactivity decay process

Due to the radioisotope of the element having an unstable nucleus, the atom particles cannot be bonded since there is no energy. The isotopes constantly decay to stabiles themselves by releasing a significant amount of energy in the form of radiation. Transmutation is referred to as the process of isotope transformation into an element of a stable nucleus. It can occur both in natural and artificial ways [Shahbazi-Gahrouei, Gholami and Setayandeh, 2013].

1-3Types of Radioactive Decay:-

There are three types, namely:

1. Alpha
2. Beta
3. Gamma

1. Alpha decay:

When an alpha particle emits its nucleus, the process is called alpha decay. The formula of alpha decay is given as [Gilmore, 2011]:

$$E = (m_i - m_f - m_p)c^2$$

Where,

- mi is the initial mass of the nucleus
- mf is the mass of the nucleus after particles emission
- mp is the mass of the emitted particle

The nucleus of helium is taken as the very stable alpha particle. It has a group of two protons and two neutrons. For example, alpha decay of uranium-238 is shown below-

$$U_{92}^{238} \rightarrow Th_{90}^{234} + He_2^4$$

Transmutation is referred to as the process of isotopes transforming into an element of a stable nucleus.

2. Beta Decay:

A beta particle is often referred to as an electron, but it can also be a positron. If the reaction involves electrons, the nucleus sheds out neutrons one by one. Even the proton number increases accordingly. A beta decay process is shown below [Gilmore, 2011]:

$$Th_{90}^{234} \rightarrow Pa_{91}^{234} + e_{-1}^{0}$$

3**. Gamma Decay**:

The nucleus has orbiting electrons, which indeed have some energy, and when an electron jumps from a level of high energy to a level of low energy, there is an emission of a photon. The same thing happens in the nucleus: whenever it rearranges into a lower energy level, a high-energy photon is shooter out, which is known as a gamma ray [Gilmore, 2011]:

1-4 review:-

According to the source of radiation, there are two types of radiation sources, natural and artificial. The natural radiations also classify into cosmic and terrestrial radiation. All of them cause internal and external exposure to the environments. The ionizing radiations from natural backgrounds are linked to human life and cannot be distinguished and far away from it. The natural background radiation exposure to the human body comes from air, water, plants animals, soil and rocks. Only those radionuclides with long half-life compared with the age of the earth (primordial) and their progenies are one of the main external exposures to the environment creatures (UNSWEAR, 2000).Everybody is inevitably exposed to natural background radiations which differ from place to place and from time to time in both quantity and quality that depend on the geological and geographical conditions (Henry, 1969).The principal sources of radiological exposure that monitor interest is due to primordial radionuclides such as 238U, 232Th and 40K..Best (, S., Farquhar son, M. and Vynckier, S., 2010).

Radioactivity in Food may be contaminated with radioactive materials due to the natural and a nuclear emergency. The vegetables and fruits will become radioactive by deposit of radioactive materials falling on that from the air or through rain water. The aims of the present work were to measure the specific activity and annual effective dose as a result of the intake of vegetables and fruits collected from local market in Najaf governor ate. Natural radioactivity was measured in samples using gamma ray spectrometer in this study. The results show that the average specific activities in vegetables samples for 238U, 232Th and 40K were 5.21, 4.76, and 186.15 Bq kg-1, respectively, the average specific activities for 232Th, 40K in fruit samples were 2.53, 211.64 Bq kg-1, while the total average annual effective dose in vegetables samples for adults, children (10 years old) and infants is estimated to be 0.117, 0.122, and 0.179 mSv, respectively, while the total average annual effective dose in fruit samples for adults, children (10 years old) and infants is estimated to be 0.141, 0.295, and 0.388 mSv, respectively. The values found for specific activity and the annual effective dose in all samples in this study were lower than worldwide median values for all groups according to UNSWEAR (2000) and ICRP (1996) respectively; therefore, these values are found to be safe.

1-5 The aim of the present study

1- To determine the activity concentration of primordial (^{238}U, ^{232}Th and ^{40}K) radionuclides in soil, fertelizer and vegetables.

2- To calculate the transfer factor from soil to different growth vegetables.

Chapter two

Experimental instrumentation

2-1Materials and methods

A total of 7 samples of different vegetables were collected. It was crushed and powdered form and each sample is about of different mass was sealed and left it for 1 month to reach secular equilibrium, where the rate of decay of the daughters becomes equal to that of the parent. This step is necessary to ensure that radon gas confined within the volume and the decay products will also remain in the sample. Table 1 shows different types of cements.

2-2Gamma ray spectrometry analysis

The spectrometers exist in the post graduate Nuclear Laboratory at Salahaddin University-Irbil. It consists of 3″×3″ NaI (Tl) detector (SILENA type model 3S3), preamplifier, amplifier, multi-channel analyzer of 512 channels of (CASSY type and model 524058) and a high voltage power supply (521681 LYBOLD) model with the range and operating voltage of 0-1500 (800 Volt). The detector resolution was measured by full width at half maximum (FWHM) of 7.4 at the 662 KeV 137Cs peak. The detector is shielded by two layers starting with copper (20mm) and lead (10 cm) in order to reduce the background radiation. A CASSY software program was used to acquire and analyze the spectrum. The cement samples were analyzed using gamma ray spectrometry for a counting time 21600 sec. Indirect methods were used to determine the specific activities of 238U and 232Th due to long life of parents. The sample concentrations of (238U,232Th and 40K) for the cements were determined in Bq/Kg from gamma ray photo peaks of 352 KeV (214Pb), 911 KeV (228Ac) and 1460(40K). The activity concentration in cement samples was calculated using the following equation (Avwiriet al.2014) Where Ns is the net peak area of a peak at a certain energy, $\varepsilon\gamma$ is the efficiency of the detector for a specific gamma ray energy, $I\gamma$ is the emission probability of radionuclide of interest, t is total counting time and ms is the mass for sediment samples.

Chapter three

Result and Discussion

3-1 Activity concentrations of natural radionuclides

The radioactivity of ^{238}U, ^{232}Th and ^{40}K ,were determined in some vegetables non-series of ^{40}K and that of decay series ^{238}U and ^{232}Th in vegetables is shown in table(1), in the pepper the specific activity of ^{40}K,^{232}Th, and ^{238}U are,1595. 79, 1.67 and 0.88(Bq/kg) respectively, among the three radionuclides, ^{40}K has the highest activity while ^{238}U has the lowest activity. In the celery the activity concentration of ^{40}K, ^{232}Th, and ^{238}U , are 2642.8, 2.78 and 13.33(Bq/kg) respectively. In the fertilizer chemistry the activity concentration of ^{40}K,^{232}Th, and ^{238}U are 124.04 ,0.495 and 0.606 (Bq/kg) respectively. In the soil the activity concentration of ^{40}K,^{232}Th, and ^{238}U are 254.33,0.538, and 0.754 respectively.in the raddish head, the activity concentration of ^{40}K,^{232}Th, and ^{238}U are 866.91,1.934 and 4.98 respectively. Finally in the raddish leaves activity concentration of ^{40}K,^{232}Th, and ^{238}U are 2051.93,1.095 and 0.996 respectively.

Table (1) Activity concentration of the natural radionuclides ^{40}K , ^{238}U and ^{232}Th measured in this work.

sample	Specific activity of primordial radionuclides in $Bq.kg^{-1}$			Transfer Factor		
	^{238}U	^{232}Th	^{40}k	^{238}U	^{232}Th	^{40}k
Pepper	0.883	1,677	8595.79	1.117	3.118	6.27
celery	13.33	2.784	2642.85	17,66	5,174	10.391
Chemistry	0.495	0.606	124.04	0.667	1.1262	0.4877
Soil	0.754	0.538	254.33	1	1	1
Radish Leaves	0.996	1.0950	2051.9	1.1319	2.035	8.0679

Radish Head	4.98	1.934	866.91	6.602	3.594	3.408

The comparison of the activity concentrations of the radionuclides in the studied vegetables with other vegetables grown and consumed elsewhere is presented in Table (2). ^{40}K in the present study is greater than the vegetables reported by (Harb, 2015) and (abojasim, 2016). The ^{232}Th and^{238}U in this study in (celery) is greater than those reported by (Harb, 2015) and (abojasim, 2019) . This variation observed in the activity concentrations is probably due to the varying climatic and geological properties of the soils and used the chemical fertilizer inتwhich these vegetables are grown.

Table (2) Comparison of the Activity Concentrations in this Study with Similar Studies.

sample	Specific activity of primordial radionuclides in Bq.kg^{-1}			references
	^{238}U	^{232}Th	^{40}k	
Pepper	0.883	1,677	8595.79	Present study
celery	13.33	2.784	2642.85	Present study
Chemistry	0.495	0.606	124.04	Present study
Soil	0.754	0.538	254.33	Present study
Radish Leaves	0.996	1.0950	2051.9	Present study
Radish Head	4.98	1.934	866.91	Present study
Celery Iraq(kufa)	ND	5.14	156.67	Abojassim, 2016

Chapter four

4-1Conclusions and Suggestions for Future Works

Based on the data analysis for vegetables, determined by using NaI(Tl) gamma ray spectrometry techniques , the following points have been concluded:

1- The specific activity of ^{238}U,^{232}Th and ^{40}K in the vegetable samples have been determined and the activity of all primordial radionuclides both ^{238}U and ^{232}Th were below the recommended value declared by UNSWEAR, but ^{40}K was above the recommended value declared by UNSCEAR2000 .

2- The determined of the transfer factor for each vegetables shows that the radionuclides in vegetables is greater than those in soil, this may related to the radionuclides present in the irrigation water and the water comes from deep origins.

Suggestion for future works

Assessment of artificial radionuclides of ^{137}Cs and ^{90}Sr in vegetables which is Available in Qasre .

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