Determination of natural radioactivity concentrations level in Soil and Transfer factors from Soil to vegetables in some irrigation land around the horticultural factory at Zuway (Batu), Shoa, Ethiopia, Using Gamma-Ray Spectrometry.

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Abstract: Assurance of naturally occurring radionuclides 226Ra, 232Th, and 40K in soil and vegetable samples were determined from tests gathered from Zuway (Batu) area, Ethiopia. The territory where the agriculture industry discharges synthetic to the lake and this water can be utilized by farmers for water system reason and the means to investigate the degree of natural radioactivity in soil and vegetables and its transfer from soil to vegetables by using a sodium iodide NaI(TI) detectors. The activity concentration of 226Ra, 232Th and 40K in soil tests were 109.06±0.027 to 157.88±0.025Bq kg/1 (normal =131.64Bkg/1), 9.03±0.009 to 14.49±0.006 Bqkg/1 (normal =10.4 Bqkg/1) and 14.55±0.004 to 34.98±0.017Bq kg/1 (normal =26.44Bqkg/1), individually. In vegetable samples (onion and cabbage) from similar areas, the radioactivity concentration of 226Ra, 232Th and 40K were 76.7±0.025 to 183.45±0.025Bq kg–1 (normal =143.39Bq kg–1), 17.7±0.008 to 33.95±0.006 Bq kg–1 (normal = 24.58Bq kg–1) and 18.66±0.059 to 58.5±0.022Bq kg–1 (normal =33.97Bq kg–1), and 13.4±0.31 to 110.1±0.05Bq kg–1 (normal =88.8Bq kg–1), 18.66±0.01 to 60.25±0.005Bq kg–1 (normal = 38.63Bq kg–1) and 8.3±0.032 to 61.6±0.027Bq kg–1 (normal =38.54Bq kg–1), individually. No 137Cs radionuclide was identified in any of the samples from this territory. The deliberate estimations of DR, Raeq, Hex, and Hin are similar to the worldwide midpoints and the qualities are beneath the breaking point. The transfer components of radionuclides in all samples were above unity. In this manner, the investigation zone spares the neighborhood network.

Introduction

Our surroundings contain naturally occurring radioactive materials that exist in all human climate; soil, water, air, food, and even our bodies contain naturally occurring radioactive materials. The presence of natural radionuclides in soil, in differing focuses, is identified with the idea of the parent rock during soil beginning [1]. Examining the transfer of normal radionuclides, as 238U, 232Th, and their daughter items are significant due to their event present wherever in the climate [2, 3]. The transfer of regular radionuclides from soil to vegetables is perceived as one of the significant pathways to people [4]. The transmission of radionuclides alongside supplements through the assimilation of minerals, and gather in different parts or even up to the eatable parts would bring about the relating increment of the radiation portion and makes sicknesses the human body.

The main boundary in the ecological security assessment of characteristic radionuclides is soil to plant transfer factors (TF) [5]. TF is fundamental for the forecast of radionuclide fixation in the climate and harvests for assessing portion influence on people [6]. Radionuclides in soils are regularly moved to various plant tissues by direct transfer through the root framework, or by the result of radionuclides and degraded soil followed by evidence on plant leaves [7]. The transfer of these radionuclides differs starting with one plant then onto the next relying upon the physical and substance properties of soil and the climate [10,11]. As of late, the assessment of radioactive isotopes in the climate and their part for living things on our planet has pulled in developing consideration, expanding radionuclide focus in the climate and compromising living beings by entering the natural pecking order from plants to creatures and, at last, to a man [8]. Rural items are essentially degraded either legitimately or in a roundabout way with natural and artificial radionuclides. Thus, the utilization of such items expands the inner radiation portion to people and contributes a huge bit to the mean annual effective dose [9].

Consequently, the transfer of natural radionuclide from soil to plant has been concentrated in various areas on the planet [12, 13, 14]. Be that as it may, there is no information on the transfer of natural radionuclides from soil to plant around the Zuway lake of Ethiopia. The current investigation expected to decide the activity concentration of naturally occurring radionuclides present in the soil and vegetables and to decide the soil- to-plant transfer components of 238U, 232Th, and 40K of certain vegetables consumed as a staple by the populaces in the East Shoa parts of Zuway (Batu) town by using NaI(TI) gamma-beam spectrometry. This is an area around the horticultural factory in Zuway (Batu), Ethiopia.

MATERIALS AND METHOD

The investigation region is close to Zuway (Batu) town, situated at 180Km toward the Southern part of the capital city of the nation, Addis Ababa. Worldwide it is found as the Lat. 70, 51'12.910 N, and longt.380; 42'29.6110 E. The investigation region comprises of prolific soil nearby farmers have been utilizing for the creation of vegetables and grain crops. Farmers began utilizing fertilizer during the 1980s, we get data from nearby farmers of the territory and agriculture utilize countless fertilizers and compound and delivered to the lake that can be utilized for water system by farmers. In nature, the soil kinds in the investigation regions are equivalent, and varieties of convergences of radioactive materials may not be normal. In any case, to get more items, the people groups are utilizing some radioactive containing fertilizers and synthetic compounds that defiled lake water for water systems that can expand the impact of radioactivity.

Fig. 1: Zuway (Batu) Lake and nearby Horticultural factories were used for irrigation and sampling areas.

Fig.2: vegetables (cabbage and onion) product around zuway horticulture that can be produced by irrigation from the lake.

Sample Collection

Two kg of the soil samples were air-dried and gone through a 2-mm work strainer. For vegetables, two kg of cabbage, and 2kg of onion tests, palatable parts were washed with deionized water, in any event, multiple times, and the evacuation of residue and soil particles was finished. The washed parts were paper-towel dried, slashed, and freeze-dried. At long last, samples of 4 soils and 8 vegetable parts were gotten and they were independently and altogether ground into fine powders. The powders were moved into plastic vials and put away at room temperature.

Sampling and Sample Preparation

An aggregate of 12 samples has been gathered which speak to the dominating soil and vegetable arrangements of the investigation region. We gathered 4 samples from the soil, 4 samples from cabbage, and 4 samples of onion from the investigation region. In the soil samples, we utilized surface inspecting procedures to the greatest profundity of 20cm and the cabbage and onion have a similar topographical and geo-substance. The cabbage and onion tests were taken from the chose region. The samples were set up in discrete receptacles for soil, cabbage, and onion separately. The eight inspecting measuring glasses for vegetables and four samplings for soil were set up after the Broiler drying of each sample at a temperature of 110^0C. The dried samples were ground to a fine powder, sieved through 0.075mm work siever (ISO-9001 and ISO-2000 quality affirmed) to the ideal size enhanced in hefty mineral for the decrease of self-retention. The last twelve samples were pressed in Pvc plastic measuring utensils of the state of Marinelli receptacles, whose volume is 150ml. At that point, we gauged and put away for a base time of 28 days to permit the in-development of uranium and thorium rot items and accomplishment of harmony with their separate offspring [15, 16]. At last, the twelve information was meant 24hours. For the investigation of the range from obscure samples, we utilized soil-6 and Soil-375 given by IAEA as references. These references were arranged and estimated by a similar philosophy as the gathered soil tests.

Each sample was estimated by gamma spectrometry with MAESTRO - 32 multichannel analyzers. . It is protected in an office of two layers beginning with the internal part tempered steel of 3 mm thick and lead of 45 mm thick to decrease foundation radiations [17]. We fixed the locator in the focal point of the chamber to limit the impact of the dispersed radiation from the

protecting materials. At that point, we saved the samples over the finder for 24 hours. The spectra were assessed physically by contrasting and the spectra from references given by IAEA recorded soil-6 and soil-375 for the energies of 238kev of Pb-212 for Th-232 distinguishing proof, 351kev of Pb-214 for U-238 ID, and 1460.9kev gamma line for K-40 movement focus [18].

Activity measurements

The time each sample checked was 24hrs and those gamma-rays spectra were examined by the Maestro-32 programming bundle for nuclide recognizable proof, top looking, top assessment, information securing, energy, and effectiveness computation. From the range investigation, check rates for each recognized photopeak and explicit movement for each of the distinguished nuclides are determined. The particular radionuclides (in Bq kg−1), A_{Ei}, of a nuclide i and for a top at energy E, is given by

$$A_{Ei} = \frac{N_{Ei}}{t \times \varepsilon_E \times \gamma_D \times M_s}$$

where N_{Ei} is the Net peak Zone of a top at energy E, εE is the identification proficiency at energy E, t is the checking live time, γ_d is the number of gammas per breaking down of this nuclide for progress at energy E, and Ms is the mass in kg of the deliberate samples. We likewise utilized this equation for the computation of exercises of reference soils and the calculation of testing materials (measuring glasses) are nearly the equivalent and we filled the readied fine powder of tests similarly. As it is now known, the movement of radioactive components in reference soil was at that point known, and we deduct the current action of sources from the date of giving by IAEA. After we found the current exercises, we utilized a near method to quantify the movement of our samples.

The last condition ought to be;

$$A_{Ei} = A_{REi} \times \frac{NPA_{(Samples)}}{NPA_{(Referencesoils)}} \times \frac{M_{(Standards)}}{M_{(Samples)}}$$

Where AsEi is the movement of photopeak from our samples (Michalis Tzortzis et al., 2012; IAEA 1998/1999, Mirions Advancements, 2017).

A few changes from decays of more long-lived radionuclides in the 238U decays chain, for samples, 214Pb, and 214Bi, were additionally used to appraise the activity concentration of 226Ra. The movement grouping of 232Th was resolved to utilize gamma-rays changes related to the decays of 228Ac, 212Pb, and 208Tl. Foundation commitments were likewise deducted from the peak regions for the deliberate samples [19,20].

Gamma dose rate

The gamma dose rates D (in nGyh/1) of the radionuclides were assessed utilizing the formula:[21]

$D = 0.429A_{Ra} + 0.666A_{Th} + 0.042A_K$ ……. 3

where A_{Ra}, A_{Th}, and A_K are the mean specific activity concentrations of Ra, Th, and K, separately, in Bq kg/1.

Radium equivalent activity

The Radium Equivalent (Raeq) record gives a rule to managing the wellbeing principles of radiation insurance for the overall population living in the researched zone. The Raeq record speaks to a weighted amount of the exercises of characteristic radionuclides. The list is given by the accompanying formula:[21]

$Raeq = A_{Ra} + 1.43A_{Th} + 0.077A_K$ ……4

where ARa, ATh, and Ak have a similar significance as in Condition 3.

External and internal hazard indices

The external radiation hazard index (Hex) due to normal gamma radiation is determined utilizing the accompanying recipe:

$$Hex = \frac{A_{Ra}}{370} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \leq 1 \qquad (5)$$

There is a radiation hazard to respiratory organs because of the 226Ra decays item 222Rn and its short-lived decays items. The greatest admissible radium fixation must be decreased to half of the typical furthest reaches of [22]. The internal hazard indices (Hin) is additionally determined utilizing the accompanying recipe:

$$Hin = \frac{A_{Ra}}{185} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \leq 1 \qquad (6)$$

where A_{Ra}, A_{Th}, and A_k have a similar significance as in conditions 3 and 4.

Transfer factors

Radionuclides in soils are much of the time moved to various plant tissues by direct exchange through the root framework, or by the aftermath of radionuclides and defiled soil followed by testimony on plant leaves [6]. The transfer factor (TF) values are determined by the condition underneath.

$$TF = \frac{Activityconcentrationinplant(Bq/kg)dryweightofplant}{activityconcentrationinsoil(Bk/kg)dryweightofsoil}$$

Soil properties that influence take-up may incorporate mineralogical and granulometric creation, natural issue substance, pH, and fertility [23].

RESULTS AND DISCUSSION

The current investigation noticed the arrangement of naturally ocurring radionuclides 238U, 232Th, and 40K in soil and vegetable samples. The state groupings of 238U, 232Th and 40K in soil tests went from 109.06±0.027 to 157.88±0.025Bq kg–1 (normal =131.64Bkg–1), 9.03±0.009 to 14.49±0.006 Bqkg–1 (normal =10.4 Bqkg–1) and 14.55±0.004 to 34.98±0.017Bq kg–1 (normal =26.44Bqkg–1), separately. In vegetable samples (onion and cabbage) from unvaried areas, the emanation convergences of 238U, 232Th and 40K were 76.7±0.025 to 183.45±0.025Bq kg–1 (normal =143.39Bq kg–1), 17.7±0.008 to 33.95±0.006 Bq kg–1

(normal = 24.58Bq kg–1) and 18.66±0.059 to 58.5±0.022Bq kg–1 (normal =33.97Bq kg–1), and 13.4±0.31 to 110.1±0.05Bq kg–1 (normal =88.8Bq kg–1), 18.66±0.01 to 60.25±0.005Bq kg–1 (normal = 38.63Bq kg–1) and 8.3±0.032 to 61.6±0.027Bq kg–1 (normal =38.54Bq kg–1), separately. No 137Cs radioactivity was recognized in any of the samples.

Tables 1 and 2 direct that the uranium action fixation was higher than that of thorium and potassium in the vast majority of the samples, which is apparent from the way that uranium is solvent in waters [24]. Table 5 shows the consequences of the current results with the acquired outcomes from different areas of the world. The concentration of 238U, 232Th, and 40K in soil and vegetable samples in this investigation was contrasted with that of various districts of the world. It was seen that the deliberate 238U activity concentration was higher than the estimations of both thorium and potassium, as uranium was the most dissolvable radionuclide in water [24]. The nonattendance of 137Cs identification in the two samples may be because of an extremely low radionuclide fixation and long half-life.

The finding from this investigation proposes that the particular activity concentration 238U, 232Th and 40K in soil tests went from 109.06±0.027 to 157.88±0.025Bq kg/1 (normal =131.64Bkg/1), 9.03±0.009 to 14.49±0.006 Bq kg/1 (normal =10.4 Bqkg/1) and 14.55±0.004 to 34.98±0.017Bq kg–1 (normal =26.44Bqkg/1), separately. In vegetable samples (onion and cabbage) from similar areas, the radioactivity coming together of 238U, 232Th and 40K were 76.7±0.025 to 183.45±0.025Bq kg/1 (normal =143.39Bqkg/1), 17.7±0.008 to 33.95±0.006 Bq kg/1 (normal = 24.58Bq kg/1) and 18.66±0.059 to 58.5±0.022Bq kg/1 (normal =33.97Bq kg/1), and 13.4±0.31 to 110.1±0.05Bq kg/1 (normal =88.8Bq kg/1), 18.66±0.01 to 60.25±0.005Bq kg/1 (normal = 38.63Bq kg/1) and 8.3±0.032 to 61.6±0.027Bq kg/1 (normal =38.54Bq kg/1), individually. The results of the particular movements of 238U were higher than the mean worldwide qualities, which might be because of the expansion of fertilizer by farmers and horticulture [25]. Table 3 looks at the transfer factors controlled by the current investigation with the world mean normal worth. The TFs from soil to vegetable (cabbage and onion), for 238U, 232Th, and 40K were 0.1 to 0.9, 2.2 to 6.7 and 0.3 to 4.2 and, 0.6 to 1.4, 1.9 to 3.76 and 0.7 to 1.7, separately, with normal TFs of 0.66, 3.54 and 1.58, and 1.03, 2.83 and 1.49, individually. The transfer factors in this investigation are higher than the world mean qualities. TFs of the concentration of the radionuclides (137Cs) were not seen in one or the other soil or vegetable samples.

Table 4. Show the consequences of Raeq for soil and vegetable samples (cabbage and onion) which range from 121.21±0.033 to 175.14±0.026Bq kg/1 (normal = 148.54Bq kg/1), and 104.3±0.32 to 184.27±0.09 Bq kg/1 (normal = 146.92Bq kg/1), and 27.08±0.045 to 203.06±0.066Bq kg/1 (normal = 136.53Bq kg/1) individually. These qualities are underneath the breaking point suggested by the Worldwide Nuclear Energy Office (IAEA) [21,22]. The absorbed dose rates were additionally introduced in Table 4 and the estimations of the dose rate because of 238U, 232Th, and 40K in soil tests differed from 52.14nGyh/1 to 75.03nGyh/1 (normal =63.81nGyh/1); for vegetable samples (cabbage and onion), these qualities fluctuated from 45.89nGyh/1 to 79.54nGyh/1 (normal = 63.64nGyh/1) and 12.01nGyh/1 to 87.16nGyh/1 (normal = 58.87nGyh/1) individually. These qualities are contrasted and the world normal of 55nGyh/1 and it's higher than the worth suggested.

The Hex and Hin regards for soil tests in Table 4 were 0.32 to 0.48 (normal = 0.41), 0.62 to 0.89 (normal = 0.76) and for vegetable (cabbage and onion) tests, were 0.28 to 0.49 (normal = 0.395), 0.33 to 0.87 (normal = 0.64) and 0.073 to 0.55 (normal = 0.37), 0.07 to 0.99 (normal = 0.54) separately. These outcomes show that Hex and Hin regard for all samples was underneath solidarity, which doesn't make hurt the surrounding network of the investigated region.

Table 5 shows the current investigation with the distributed information from a comparative report in different parts of the world. The activity concentration of 238U in these works is higher than the world normal [19]. The mean activity concentration of 232Th is lower than Md Altaf Hassen (2015), Theophilus Adjirackor (2020), and Hasan et al (2011) however it is higher than Murtadha Sh. Aswood (2013). The mean activity concentration of 232Th is below the world normal [19]. In another manner, the concentration of 40K is fundamentally lower than the grouping of 238U and 232Th and consequently, the mean activity concentration of 40K in this investigation is below the world normal. The mean annual effective dose in soil samples is 0.075mSvy/1 and for vegetable (cabbage and onion) is additionally 0.074mSv/y and 0.068 mSv/y. The mean annual effective dose in this investigation is underneath the world's normal breaking point suggested by [18].

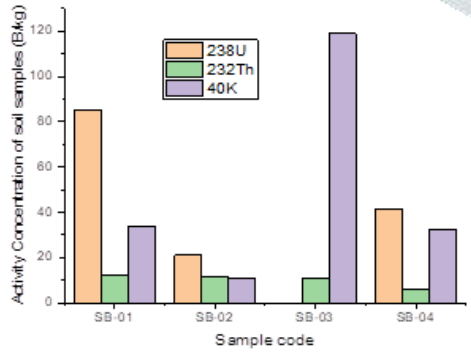

Fig.1: Activity concentration of 28U, 232Th, and 40K in soil samples.

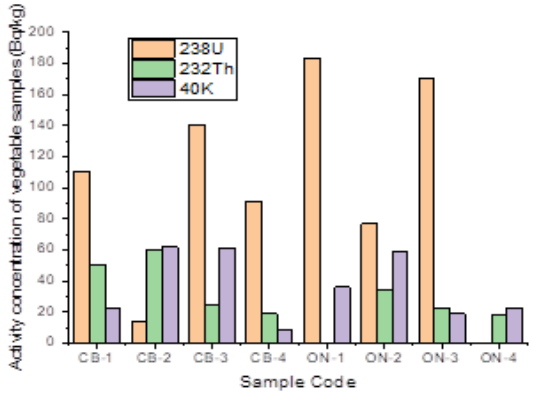

Fig.2: Activity concentration of 28U, 232Th, and 40K in vegetable samples.

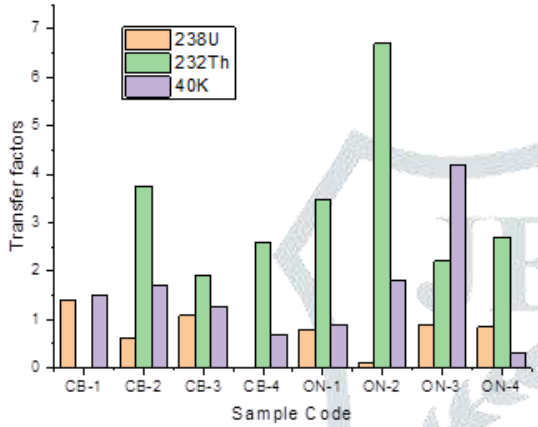

Fig.3: Transfer factors of radionuclides from soil to vegetables.

S. N	Activity concentration in Onion			Activity concentration in soil			Transfer factors		
	238U	*232Th*	*40K*	*238U*	*232Th*	*40K*	*238U*	*232Th*	*40K*
1	183.45±0.025	-	35.93±0.032	133.6±0.026	14.49±0.006	24.41±0.022	1.4	-	1.5
2	76.7±0.025	33.95±0.006	58.5±0.022	126±0.026	9.03±0.009	34.98±0.017	0.6	3.76	1.7
3	170.03±0.029	22.09±0.008	18.66±0.059	157.88±0.025	11.29±0.007	14.55±0.004	1.08	1.9	1.28
4	-	17.7±0.008	22.79±0.044	109.06±0.027	6.8±0.01	31.82±0.016	-	2.6	0.7
Mean	143.39±	24.58	33.97	131.64	10.40	26.44	1.02	2.75	1.3

Table 1. *Activity concentration of natural radionuclides in vegetable (Onion) and corresponding soil samples and transfer factors.*

S. N	Activity concentration in Cabbage			Activity concentration in soil			Transfer factors		
	238U	*232Th*	*40K*	*238U*	*232Th*	*40K*	*238U*	*232Th*	*40K*
1	110.1±0.05	50.64±0.006	22.77±0.08	133.63±0.026	14.49±0.006	24.41±0.022	0.8	3.49	0.9
2	13.4±0.31	60.25±0.005	61.6±0.027	12±0.026	9.03±0.009	34.98±0.017	0.1	6.7	1.8
3	140.62±0.04	24.97±0.009	61.48±0.025	157.88±0.025	11.29±0.007	14.55±0.004	0.9	2.2	4.2
4	91.09±0.045	18.66±0.01	8.3±0.032	109.06±0.027	6.8±0.01	31.82±0.016	0.84	2.7	0.3
Mean	88.8	38.63	38.54	103.14	10.4	26.44	0.66	3.77	1.8

Table 2. Activity concentration of natural radionuclides in vegetable (Cabbage) and corresponding soil samples and transfer factors.

S. Code	*238U*	*232Th*	*40K*
ON-1	1.4	-	1.5
ON-2	0.6	3.76	1.7
ON-3	1.08	1.9	1.28
ON-4	-	2.6	0.7
Mean	1.03	2.83	1.49
CB-1	0.8	3.49	0.9
CB-2	0.1	6.7	1.8
CB-3	0.9	2.2	4.2
CB-4	0.84	2.7	0.3
Mean	0.66	3.54	1.58

Table 3. The transfer factor (TF) values of radionuclides from soil to vegetable (Onion and Cabbage).

S. Code	***Raeq(B/kg)***	***DR(nGy/h)***	***ADR(mSv/y)***	***Hin***	***Hex***
SB-01	156.23±0.034	67.14	0.08	0.47	0.77
SB-02	141.59±0.032	60.93	0.07	0.38	0.74
SB-03	175.14±0.026	75.03	0.09	0.48	0.89
SB-04	121.21±0.033	52.14	0.06	0.32	0.62
Mean	148.54	63.81	0.075	0.41	0.76
CB-1	184.27±0.09	79.54	0.09	0.49	0.78
CB-2	104.3±0.32	45.89	0.056	0.28	0.33
CB-3	181.06±0.32	78.24	0.09	0.49	0.87
CB-4	118.06±0.048	50.88	0.06	0.32	0.56
Mean	146.92	63.64	0.074	0.395	0.64
ON-1	101.1±0.64	79.87	0.09	0.49	0.99
ON-2	186.22±0.058	56.42	0.07	0.35	0.54
ON-3	129.75±0.043	87.16	0.1	0.55	0.55
ON-4	203.06±0.066	12.01	0.01	0.073	0.073
Mean	27.08±0.045	58.87	0.068	0.37	0.54

Table 4. The radium equivalent (Raeq), absorbed doses (DR), Annual effective dose (ADR) the external (Hex), and the internal (Hin) hazard index of soil (SB), cabbage (CB), and onion (ON) samples.

Conclusion

The measure concentrations of 238U, 232Th, and 40K in soil and vegetable samples and its transfer factors from soil to vegetables from the Zuway horticulture area have been considered using NaI(TI) gamma-rays spectrometry detectors. The mean activity concentration of 238U, 232Th, and 40K in the soil and vegetable samples were assessed to be 103.14, 10.4, and 26.44Bqkg-1, while in the vegetable (cabbage and onion) was 88.8, 38.63 and 38.54 Bqkg-1 and 143.39, 24.58 and 33.97 Bqkg-1 individually. The consequences of the mean activity concentration of 238U in the soil and vegetable samples are higher than the world normal. The mean compelling portion of this investigation is lower when contrasted with the world normal (UNSCEAR, 2000). The mean concentration of 40K and the viable portion in the soil and vegetable samples are below the world normal however transfer factors for 40K are bigger than the cutoff in the investigation territory. The consequences of this investigation territory show that there are low degrees of characteristic radionuclides and the regions are underneath the overall normal breaking point. Accordingly, horticulture has no negative effect on the climate and doesn't represent a radiological peril to the general population.

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