Soil and Coal Radioactivity around Zuunmod Town of Mongolia

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ABSTRACT

The specific radioactivity concentrations of ^{238}U, ^{232}Th, ^{40}K were measured in soil samples around Zuunmod town of Mongolia using HP-Ge gamma-spectrometer. Also the specific radioactivity concentrations of above elements were measured in coal and ash samples which were collected from the Central steam heating in Zuunmod town. It was determined the effective equivalent dose.

Keywords: specific radioactivity, gamma-spectrometer, effective equivalent dose

1. INTRODUCTION

Most of electric and heating power necessity is supplied by the station with coal burning technology in Mongolia Also during cold seasons the coal is used for heating in national house-ger, in which live many people. Nature radioactive isotopes, which were enriched in ash and slug, are considered as a source of internal and external exposure of inhabitants. In Zuunmod town of Mongolia the heating is supplied by 1 centralized station and five small stations and in which is used about 400 ton of coal. There are 2160 gers in Zuunmod town. So it would be 86.4 ton of coal for all the gers per twenty four hours.

In this work were determined special radioactivity concentrations of ^{238}U, ^{232}Th, ^{40}K, ^{226}Ra in soil samples, which were collected from 5 different points around Zuunmod town. Also it was established the dose of external exposure of inhabitants in Zuunmod town.

2. EXPERIMENTAL

2.1 The soil radioactivity around Zuunmod town

The structure of nature and artificial radioactive isotopes and specific radioactivity concentrations of ^{238}U, ^{232}Th, ^{40}K were measured by HP-Ge gamma spectrometer.

There was drugged soil with depth 5 centimeter and square 10x10 cm from points N1, N2, N3, N4 and Zuunmod town (Figure 1). Each soil sample put into 450 ml Marinelli vessel and measured for one hour.

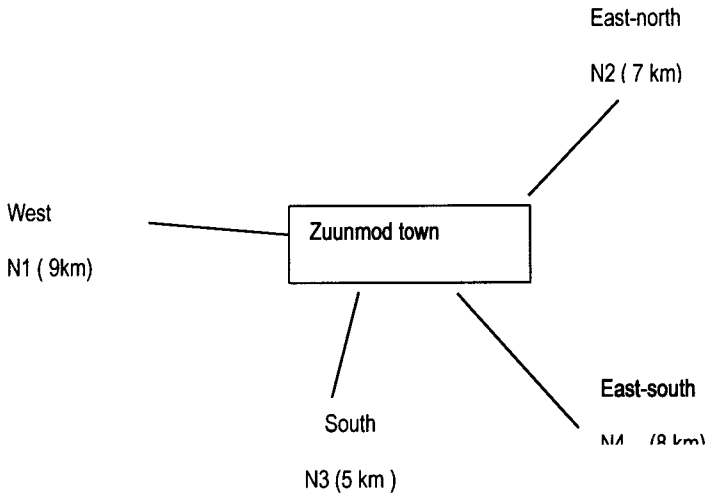

Figure 1.

It was used the formula to determine specific radioactivity of radioactive isotopes:

$$A = \frac{N(E_i)}{k \cdot \varepsilon_0(E) \cdot k_\gamma \cdot m \cdot t};$$

where: A- specific radioactivity of radioactive isotopes (Bq/kg), N(E)- Peak area , $\varepsilon_0(E)$- detector efficiency for water(ρ=1 g/cm^3), k-correction factor for different density of soil and water, m –sample mass(kg), t- measured time(sec).

It was used the formula to determine ^{137}Cs accumulation in a soil with depth 5 cm.

$$A_{Cs} = \frac{N \cdot m_{all}}{0.851 \cdot k \cdot \varepsilon_0(661.7keV) \cdot 50 \cdot S \cdot t \cdot m_{me}};$$

where: A_{Cs}- ^{137}Cs accumulation in a soil (Bq/m^2)
50- transfer constant for units
m_{all}- mass of soil sample (kg)
m_{me}- mass of measured soil sample (kg)
S- drugged soil square (m^2)

A specific radioactivity concentration of ^{226}Ra in a soil was determined by the line 609.31 keV (^{214}Bi). The radioactive equilibrium between the ^{238}U and ^{226}Ra was checked. To determine a specific radioactivity concentration of ^{232}Th were registrated γ-rays of 583.19 keV(^{268}Tl), 911.16 keV (^{228}Ac). A specific radioactivities of ^{40}K and ^{137}Cs were determined by gamma lines with 1460.75 keV and 661.66 keV, respectively.

The specific radioactivity of radioactive elements in soils around Zuunmod town was shown in table 1.

Table.1.

Soil sampling Points	Sample No.	Specific radioactivity (Bq/kg)			^{137}Cs-(kBq/m^2)	Element concentration		
		^{238}U	^{232}Th	^{40}Ê		U (g/ton)	Th (g/ton)	K (%)
Zuunmod	1	28.3±4.1	19.3±6.6	757.3±4.2		2.3	4.74	2.5
	2	25.2±4.5	22.6±7.9	754.4±4.3		2.1	5.5	2.5
	3	56.0±3.4	28.05±7.3	638.0±4.9	4.2± 0.6	4.6	6.9	2.1
	4	53.6±3.2	32.6±6.5	600.5±4.8	4.1±0.6	4.4	8.0	2.0
	5	24.7±4.6	28.5±6.9	688.2±4.2		2.0	7.0	2.3
	Mean	37.6±4.0	26.2±7.0	687.7±4.5	4.1±0.6	3.1	6.4	2.3
N1	1	21.6±4.5	29.7±5.3	801.6±3.7		1.8	7.3	2.7
	2	23.6±4.0	34.3±5.1	655.0±4.0		1.9	8.4	2.2
	3	22.3±4.1	25.5±5.9	719.0±3.8	3.0±0.4	1.8	6.3	2.4
	4	21.0±4.4	27.7±5.8	713.1±3.9	1.7±0.3	1.7	6.8	2.4
	5	24.8±4.5	30.5±6.2	847.6±4.0		2.0	7.5	2.8
	Mean	23.0±4.3	29.5±5.6	747.3±3.9	2.4±0.4	1.8	7.3	2.5
N2	1	27.4±4.0	45.1±4.6	775.3±4.0	3.6±0.4	2.2	11.0	2.6
	2	32.2±4.5	49.7±5.4	872.7±4.3	4.7±0.5	2.6	12.2	2.9
	3	28.2±4.8	49.1±5.5	520.2±5.3	5.8±0.6	2.3	12.0,	1.7
	4	20.7±3.7	34.2±4.6	921.0±3.1		1.7	8.4	3.1
	5	39.1±4.0	53.1±5.3	676.3±4.8	6.9±0.7	3.2	13.0	2.3
	Mean	29.5±4.2	46.3±5.1	753.1±4.3	5.3±0.6	2.4	11.4	2.5
N3	1	27.6±4.3	40.1±5.3	748.8±4.2	5.2±0.6	2.3	9.8	2.5
	2	38.2±3.8	53.5±4.7	951.9±3.7	1.4±0.3	3.1	13.1	3.2
	3	22.7±4.6	31.8±5.3	809.4±3.7		1.9	7.8	2.7
	4	21.7±4.8	37.7±5.2	787.2±3.7		1.8	9.2	2.6
	5	17.6±4.3	29.7±4.7	701.7±3.3		1.4	7.3	2.3
	Mean	25.6±4.4	38.5±5.1	799.8±3.7	3.3±0.4	2.1	9.4	2.7
N4	1	27.5±3.1	24.2±5.1	768.7±3.3		2.3	5.9	2.6
	2	19.7±3.9	23.9±5.2	755.3±3.4		1.6	5.9	2.5
	3	27.5±4.0	35.9±5.7	893.2±3.9	3.0±0.4	2.3	8.8	3.0
	4	27.9±3.9	34.2±5.1	699.1±4.1		2.3	8.4	2.3
	5	18.05±4.3	22.8±5.4	693.6±3.4		1.5	5.6	2.3
	Mean	24.1±3.8	28.2±5.3	762.0±3.6	3.0±0.4	2.0	6.9	2.5

These results were compared with mean values in other cities of Mongolia and some country and world mean value in table 2 .

Table.2.

City name and country		Specific radioactivity concentrations (Bq/kg)		
		^{238}U	^{232}Th	^{40}K
Mongolia Mongolia	Zuunmod	37.6±4.0	26.2±7.0	687.7±4.5
	Khovd	26.2±5.3	28.8±4.3	754.0±4.3
	Uvs	25.0±0.7	68±0.6	434.0±16
	Ulaanbaatar	33.0±9.0	39±0.7	880.0±9.5
	Erdenet	25.0±0.6	18±1.0	440.0±5.0
	Dornod	15.0±2.0	14±2.0	965.0±6.0
	Darkhan	45.0±4.0	33±1.6	735.0±5.5
World mean (range)		25.0 (10-50)	25.0 (7-50)	370.0 (100-700)
China (range)		40.0±34 (1.8-520)	49.0±28 (1.5-440)	580.0±20 (12-2190)
USA (range)		35.0 (4-140)	35.0 (4- 130)	370.0 (100-700)

2.2 Radioactive backgrounds

The absorbed dose rate(nGy/h) was calculated in an air following formula.

$$P=0.427\ A_U+0.66\ A_{Th}+0.0043\ A_K$$

where: A_U, A_{Th}, A_K - specific radioactivity concentrations of ^{238}U, ^{232}Th and ^{40}K, respectively.
The effective equivalent dose from gamma-ray of radioactive isotopes was obtained by the equation:

$$D(\mu Sv) = 0.2xP(nGy/h)x0.7(Sv/Gy)x8760(h/yr)x10^3$$

The radioactive background around Zuunmod town and effective equivalent dose of inhabitants per year were shown in table 3.

Table 3.

Sampling points	^{238}U, ^{232}Th , ^{40}K		^{137}Cs	
	Ð(nGy/h)	D(μSv)	Accumulation (kBq/m^2)	D(μSv)
Zuunmod	69.0	84.6	4.1	37.0
N4	62.0	76.0	3.0	27.0
N1	61.4	75.3	2.4	22.0
N2	75.6	92.8	5.3	48.0
N3	57.4	70.4	3.3	30.0
Mean	65.08	79.8	3.6	32.0
Ulaanbaatar	77.7	95.0	5.0	45.0
World mean	50.0	61.0	5.2	47.0

2.3 Ash and coal radioactivity of central steam heating station in Zuunmod town

The specific radioactivity of ^{238}U, ^{232}Th, ^{40}K in ash samples from central steam heating station was determined (Table 3). Also the summary radioactivity was calculated by following formula.

$$A = A_U + 1.3A_{Th} + 0.09A_K < 370 \text{ Bq/kg}$$

The specific radioactivity in coal and ash samples was shown in table 4.

Table 4.

Samples	Sample No.	The specific radioactivity (Bq/kg)			Summary radioactivity(Bq/kg)
		^{238}U	^{232}Th	^{40}K	
Coal	1	15.5	6.1	82.5	
	2	14.6	15.9	53.0	
	3	24.3	16.8	67.2	
	4	23.5	20.9	13.8	
	Mean	19.5	14.9	54.1	
Ash	1	151.0	60.7	210.0	248.6
	2	133.0	65.7	179.0	234.4
	3	108.0	71.8	297.0	228.2
	4	99.6	72.3	262.0	217.2
	Mean	123.0	67.7	237.0	232.1

3. CONCLUSION

1. Specific radioactivity of ^{238}U and ^{232}Th in soil samples of Zuunmod town is in agreement with word mean and mean values of Ulaanbaatar and Darkhan cities of Mongolia. But the specific radioactivity of ^{40}K is higher than the world mean. These discrepancies element composition of soil.
2. Radioactive background of the center of Zuunmod and N4, N1, N2 and N3 were 69nGy/h, 62nGy/h, 61.4nGy/h, 75.6nGy/h, 57.4nGy/h, respectively. The mean value of these results was 1.2 times less than the Ulaanbaatar, but 1.3 times higher than the world mean.
3. Specific radioactivity values of ^{238}U and ^{232}Th in an ash of the steam heating station are 8 times higher than in a coal. The summary radioactivity of these elements in the ash was 232 Bq/kg and it was less than living house standard in Russia (370Bq/kg).

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