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Research Article**SOIL RADIOACTIVITY IN THE SOME PETROLEUM EXPLORATION FIELDS OF MONGOLIA****Erdenetuya MYAGMAR^{1*}, Erkhembayar TSEWEEN² and Norov NANZAD³**¹Department of Physics School of Applied Science, Mongolian University of Science and Technology² Nuclear Research Center, National University of Mongolia and³Environmental Engineering, University of Kitakyushu**ARTICLE INFO****Article History:**Received 05th February, 2016Received in revised form 21st March, 2016Accepted 06th April, 2016Published online 28th May, 2016**Keywords:**

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ABSTRACT

This work was focused on determination of specific radioactivity of ²³⁸U, ²³²Th, ⁴⁰K and ¹³⁷Cs in soil samples, effective equivalent dose and radiation background in around some petroleum exploration fields of Matad town and Tamsag basin of Dornod province and Zuunbayan town of Dornogovi province. We have determined dose rate and specific radioactivity of natural and artificial radioactive isotopes around petroleum exploration fields by using the HP-Ge gamma-spectrometer. The results were compared with the world mean value.

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INTRODUCTION

The geologic fieldworks conducted in Mongolia have revealed many similarities between the Chinese Erlian and Hailar basins and eastern Mongolian basins such as Tamsag and East Gobi.



Figure 1 East Gobi basin of Mongolia

Laboratory analysis of oil samples from Zuunbayan and Tsagaan Els fields and oil samples from Tamsag shows that crude oil from East Gobi is similar to the Chinese crude (high pour point and waxy crude) in Erlian and Hailar basins and even better in case oil discovered in Tamsag basin.

Petroleum contains a certain percent of natural radioactive elements. As a result of the decay of uranium and thorium, and the leaching of the host rocks for oil are constantly formed radioisotopes of radium (²²⁶Ra, ²²⁸Ra). In the liquefied oil are natural traps, intensive exchange of radium between oil and prop up its waters there, resulting in an excess of radium in oil. In developing the field of formation and injected water intensely come into the oil reservoir, the surface of the water-oil increases dramatically, resulting of radium goes into the stream of water percolation. So it is urgently needed to make research on radiation monitoring, especially determination of natural radioactive elements in industrial wastes.

Thus, it is necessary to make radiation background researches in places, which have biggest petroleum resources in Mongolia, such as Zuunbayan, Matad and Tamsag.

In this paper were shown measurement results of dose rate and specific radioactivity of natural and man-made radioactive isotopes around petroleum exploration field of Matad town and Tamsag basin of Dornod province and Zuunbayan town of Dornogovi province by using the HP-Ge gamma-spectrometer. There were taken soil samples from the petroleum exploration field of Matad town and Tamsag basin of Dornod province and Zuunbayan town of Dornogovi province and determined

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specific radioactivity of ^{238}U , ^{232}Th , ^{40}K and ^{137}Cs in soil samples.

METHODOLOGY

In order to evaluate the inventory of the environmental radiation levels in the Matad town and Tamtsag basin of Dornod province and Zuunbayan town of Dornogovi province, soil samples were appropriately collected and analyzed in the laboratory by gamma spectrometry. Surface soil of the vicinity of the Matad town and Tamtsag basin of Dornod province and Zuunbayan town of Dornogovi province was sampled from 15 x 15 cm square area and 5 cm in depth. Soil sample was put into the Marinelli-beaker with capacity of 700 mL and measured for 3600 s at gamma spectrometry of Nuclear Research Center, National University of Mongolia. The samples were measured for 3600 s in a high resolution gamma-spectrometry system, incorporating an HPGe detector of 20 % relative efficiency and a computerized multichannel analyzer of 4096 channels.

Gamma measurements were performed with a typical high-resolution gamma spectrometer based on a shielded High-Purity Germanium (HPGe) detector, coaxial type, with 52cm^3 effective volume and energy resolution of 2.0 keV FWHM for the 1332 keV gamma ray line of Co^{60} . The detector was coupled to the Multi Channel Analyzer system (MCA) and PC board card S-100 Canberra analyzer. The spectrometer was calibrated using 1000mL, 700mL Marinell liquid calibration source of Am^{241} , Cd^{109} , Co^{57} , Ce^{139} , Cs^{137} , Y^{88} and Co^{60} traceable to international standards and emitting γ -rays in the energy range of 59-1836 keV. Calculated values of specific activity of Ra^{226} , Th^{232} , K^{40} and Cs^{137} were based on the most intensive gamma energy of 609.3 keV (Bi^{214}), 581.3 keV (Tl^{209}), 1460 keV and 661.7 keV, respectively. The following formula has been used to determine the specific activity of radioactive isotope within soil by using the total

absorption peak (Sourses, Effects and Ricks of Ionizing Radiation, 1993):

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

Where: A – specific radioactivity (Bq/kg); $N(E_i)$ – area under of total absorption peak γ -rays with the energy E_i ; k – geometry factor of the detector; $\varepsilon_0(E_i)$ - detector efficiency; k_γ - gamma ray emission factor; m – sample mass (kg); t – measuring time (sec);

External gamma radiation levels around the petroleum exploration field were measured using gamma survey meters (AT-6130, ATOMTEX Russian Company) and showed results of measurement in table1. Absorbed gamma dose rate in the air at 1 m above the ground surface for the uniform distribution of radionuclides (U-238, Th-232 and K-40) were calculated by following formula by using the following equation (Study of soil radioactivity by gamma spectrometer method, 1998):

$$P_{abs} = 0,427 A_U + 0,662 A_{Th} + 0.043 A_K$$

Where: A_{Ra} , A_{Th} , A_K – Ra-226, Th-232, K-40 - the specific activity (Bq/kg); P_{abs} - absorbed dose rate (nGy/h)

The effective equivalent dose from gamma-ray of radioactive isotopes was obtained by the equation (Study of Soil Radioactivity around Central region of Mongolia, 2009):

$$D(\mu\text{Sv}) = 0.2 \times P \left(\frac{\text{nGy}}{\text{hour}} \right) \times 0.7 \left(\frac{\text{Sv}}{\text{Gy}} \right) \times 8760 \left(\frac{\text{hour}}{\text{year}} \right)$$

EXPERIMENTAL RESULTS

The results of the radionuclide determination in soil samples are presented in tables 1, 2, 3 and 4. Lowest value of radium specific radioactivity belongs to sample number 20, highest value of radium belongs to sample number6, lowest value of

Table 1 Radioactivity levels in soil samples and absorbed dose rate (Dornod Matad town)

№	Sample name	Specific activity of elements, (Bq/kg)				Content of elements			P_{abs} (nGy/h)
		^{226}Ra	^{232}Th	^{40}K	^{137}Cs	U, ppm	Th, ppm	K, %	
1	sample №1	19.6	11.6	1026	5.3	1.6	2.8	3.4	60.2
2	sample №2	39.8	13.4	1064	6.8	3.3	3.3	3.5	71.6
3	sample №3	24.1	10.5	1062	15.9	2.0	2.6	3.5	62.9
4	sample №4	40.6	9.3	1094	2.2	3.3	2.3	3.7	70.5
5	sample №5	21.8	11.4	1070	1.8	1.8	2.8	3.6	62.8
6	sample №6	45.3	14.8	995	3.7	3.7	3.6	3.3	71.9
7	sample №7	33.6	12.1	1066	6.4	2.8	3.0	3.6	68.2
8	sample №8	17.5	5.1	559	1.2	1.4	1.3	1.9	34.9
9	sample №9	36.6	11.2	971	2.1	3.0	2.8	3.2	64.9
10	sample №11	27.8	10.9	1061	17.2	2.3	2.7	3.5	64.8
11	sample №10	30.7	12.2	1119	1.0	2.5	3.0	3.7	69.3
12	sample №12	18.4	7.2	942	2.5	1.5	1.8	3.1	53.1
13	sample №13	17.8	9.8	1057	1.1	1.5	2.4	3.5	59.6
14	sample №14	34.1	13.1	1103	16.3	2.8	3.2	3.7	70.6
15	sample №15	25.2	7.7	866	12.7	2.1	1.9	2.9	53.1
16	sample №16	25.7	9.0	876	3.1	2.1	2.2	2.9	54.6
17	sample №19	22.6	7.9	711	14.2	1.9	1.9	2.4	45.4
18	sample №17	28.0	9.6	880	10.6	2.3	2.4	2.9	56.1
19	sample №18	29.0	9.4	1086	1.0	2.4	2.3	3.6	65.3
20	sample №20	15.5	4.2	856	3.0	1.3	1.0	2.9	46.2
	Average	27.7	10.0	973	6.5	2.3	2.5	3.2	
	World mean[2,3]	25.0	25.0	370.0	12.3	2.0	6.1	1.2	

thorium specific radioactivity belongs to sample number 20, highest value of thorium belongs to sample number 6, lowest value of potassium specific radioactivity belongs to sample number 8, highest value of potassium radioactivity belongs to sample number 10, lowest value of cesium specific radioactivity belongs to sample number 10, 18, highest value of cesium radioactivity belongs to sample number 11. In sample number 20 we can see the same lowest values of radium and thorium. In sample number 6 can see the same highest values of radium and thorium.

sample number 5. In sample number 16 we can see the same lowest values of radium, thorium and potassium. In sample number 5 can see the same highest values of radium, thorium and potassium.

Lowest value of radium specific radioactivity belongs to sample from borehole 19-12, highest value of radium belongs to sample from borehole 19-3, lowest value of thorium specific radioactivity belongs to sample from borehole 19-12, highest value of thorium belongs to sample from borehole 19-3, lowest

Table 2 Radioactivity levels in soil samples and absorbed dose rate (Zuun-Bayan)

№	Specific activity of elements, (Bq/kg)				Content of elements			P_{abs} (nGy/h)
	²²⁶ Ra	²³² Th	⁴⁰ K	¹³⁷ Cs	U, ppm	Th, ppm	K, %	
1	31	33	1089	12	2.6	8.1	3.6	82
2	32	28	1062	6	2.6	6.8	3.5	78
3	29	19	930	25	2.4	4.6	3.1	65
4	21	22	1048	43	1.7	5.3	3.5	69
5	59	53	2396	67	4.9	12.9	8	163
6	22	25	1066	26	1.8	6.1	3.6	72
7	13	14	967	7	1.1	3.4	3.2	56
8	14	13	833	15	1.1	3.3	2.8	51
9	28	17	989	13	2.3	4.2	3.3	66
10	18	18	946	17	1.5	4.4	3.2	60
11	30	19	876	20	2.4	4.6	2.9	63
12	22	20	893	17	1.8	4.8	3	61
13	28	22	1023	20	2.3	5.4	3.4	71
14	24	31	1046	17	1.9	7.6	3.5	75
15	31	31	460	9	2.6	7.7	1.7	25
16	9	7	324	8	0.7	1.8	1.1	23
17	12	13	434	6	1	3.3	1.4	33
Average	25	23	964	17	2.1	5.5	3.2	66
World mean values[1]	25	25	370	27	2.0	5.2	1.4	43

Table 3 Radioactivity levels in soil samples and absorbed dose rate (Tamtsag basin)

№	Sample name	Specific activity of elements, (Bq/kg)				Content of elements			Accumulation of Cs ¹³⁷ (kBq/m ²)
		²²⁶ Ra	²³² Th	⁴⁰ K	¹³⁷ Cs	U, ppm	Th, ppm	K, %	
1	Borehole19-3	23.7	26.2	783.6	5.2	1.9	6.4	2.6	1.0
2	In front of the industry base	14.4	16.4	773.6	12.5	1.2	4.0	2.6	2.4
3	Borehole 19	18.2	22.7	746.3	20.8	1.5	5.6	2.5	4.0
4	Borehole 19-10	17.4	15.6	877.8	13.2	1.4	3.8	2.9	2.5
5	Camp of Chinese worker	19.8	16.9	864.9	8.9	1.6	4.1	2.9	1.7
6	Borehole 19-12	13.7	15.5	727.2	11.6	1.1	3.8	2.4	2.2
Average		17.9	18.9	795.6	12	1.5	2.7	2.7	2.3
World mean values[1]		25	25	370	27	2.0	6.1	1.2	5.1

Table 4 Population annual effective equivalent dose from cosmic rays and soil

Location	Cosmic rays		Ground soil		Cesium-137		Total
	nGy/h	μSv	nGy/h	μSv	kBq/m ²	μSv	
Zuunbayan	50	428	66	81	17	30	539
Erdene-Tsagaan	43	369	57.2	69	7.7	13	451
Matad	39	358	63.8	78	5.8	10	446
Tamtsag	39	335	52.8	64	2.4	22	421
World mean[1]	43	370	50	61	27	47	478

Lowest value of radium specific radioactivity belongs to sample number 16, highest value of radium belongs to sample number 5, lowest value of thorium specific radioactivity belongs to sample number 16, highest value of thorium belongs to sample number 5, lowest value of potassium specific radioactivity belongs to sample number 16, highest value of potassium radioactivity belongs to sample number 5, lowest value of cesium specific radioactivity belongs to sample number 2, 17, highest value of cesium radioactivity belongs to

value of potassium specific radioactivity belongs to sample from borehole 19-12, highest value of potassium radioactivity belongs to sample from borehole 19-10, lowest value of cesium specific radioactivity belongs to sample from borehole 19-3, highest value of cesium radioactivity belongs to sample from borehole 19. In sample from borehole 19-12 we can see the same lowest values of radium, thorium and potassium. In sample from borehole 19-3 can see the same highest values of radium, thorium.

In Matad town and Tamtsag basin population annual effective equivalent dose from cosmic rays was 1.1 times lower than world mean. In Zuunbayan town population annual effective equivalent dose from cosmic rays was 1.15 times higher than world mean.

The results of the radionuclide determination in Tamtsag XIX potential area samples, which were collected waste water from 19-31 well, where was 710m above sea level, located in north latitude 47°01'47.11", east longitude 116°08'24.711", and boring

liquid waste from 19-13-2 well, where was 659m above sea level, located in north latitude $47^{\circ}54'474''$, east longitude $116^{\circ}15'597''$ were presented in table 5.

Table 5 The specific activity of natural radioactive isotopes in waste water

№	Sample	Volume specific activity (Bq/l)			
		²¹⁴ Pb	²¹⁴ Bi	²²² Rn	²²⁶ Ra
1	Borehole 19-27	34.5	40.7	37.6	52.6
2	Borehole 19-31, 710m	995.6	1347	1171	11.1
3	Borehole 19-27 , 654m	1820.6	2344	2082	<0.4

CONCLUSION

1. Average specific activity of ²³⁸U in Erdenetsagaan town of Sukhbaatar province was 1.1 times higher than world mean, in Tamsag basin of Dornod province was 1.4 times lower than world mean, in other points it was comparable with world mean.
2. Average specific activity of ²³²Th in Zuunbayan town of Dornogovi province was comparable with world mean value. In other points it was 1.3-2.5 times lower than world mean.
3. Average specific activity of ⁴⁰K in above mentioned points was 2.3-2.6 times higher than world mean. It depends on soil structure.
4. Annual equivalent effective dose from external exposure of Zuunbayan town of Dornogovi province was 1.13 times higher than world mean. In other points it was lower than world mean.
5. The specific activity of Ra²²⁶ and Th²³² of soil samples, which were collected from waste water distributed surfaces of 19-3rd well, was 1.4 and 1.5 times higher than the other samples. It means soil surface was polluted by oil.

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6. Lowest value of Cesium in above mentioned points shows that in this area soil erosion was very high.

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