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Radioactive background in some uranium deposits of Mongolia

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----------ABSTRACT----------

Objective. *The aim of our research was to determine high radioactive points and radiation background in uranium deposit area, predict radiation hazards to population.*

Method: *Using specific radioactivity concentrations of ^{238}U, ^{232}Th, ^{40}K, which were collected from some points of uranium deposits in Mongolia, we have determined dose rate and effective equivalent dose in Gurvanbulag, Khairkhan, Dulaan-Uul, Zuuvch-Ovoo uranium deposits in Mongolia. Also we had determined radioactivity in soil, water, animal milk and air samples by HP-Ge gamma-spectrometer, which were collected in these four biggest uranium deposits of Mongolia.*

Results*. Maximum value of Gurvanbulag uranium deposit dose rate in Bayandun town of Dornod province was 1516.9 nGy/h, which was 29.27 times higher than world mean. Minimum value of dose rate in Gurvanbulag uranium deposit was 31.5 nGy/h, which was 1.65 times lower than world mean. Maximum value of effective equivalent dose in Gurvanbulag uranium deposit was 1860.3 μSv, which was 29.2 times higher than world mean. Minimum value of effective dose rate in Gurvanbulag uranium deposit was 38.6 μSv, which was 1.65 times lower than world mean. Maximum value of Dulaan-Uul uranium deposit dose rate in Ulaanbadrakh town of Dornogovi province was 258.7 nGy/h, which was 10.16 times higher than world mean. Minimum value of dose rate in Dulaan-Uul uranium deposit dose was 53.9 nGy/h, which was in the range of world mean. Maximum value of effective equivalent dose in Dulaan-Uul uranium deposit was 317.3 μSv, which was 4.97 times higher than world mean. Minimum value of effective dose rate was 66.1 μSv, which was in the range of world mean. Maximum value of Khairkhan uranium deposit dose rate in Dornogovi province was 105.5 nGy/h, which was 2.02 times higher than world mean. Minimum value of dose rate in Khairkhan uranium deposit was 61.2 nGy/h, which was 1.12 times higher than world mean. Maximum value of effective equivalent dose was 129.4 μSv, which was 2.02 times higher than world mean. Minimum value of effective dose rate in Khairkhan uranium deposit was 75.07 μSv, which was 1.17 times higher than world mean. ^{214}Bi volume radioactivity in Dulaan-Uul uranium deposit was 1.19 times higher than spring water sample. In other samples volume radioactivity of elements was lower or comparable with spring water sample. Radioactive isotopes ^{214}Pb, ^{214}Bi, ^{222}Rn, ^{222}Ra in camel and cow milk were in the range of lower limit of detection, but ^{137}Cs camel and cow milk, camel yogurt was 18.5-38.5 times lower than acceptable level. Radon volume radioactivity in the open field of Gurvanbulag uranium deposit area was 25.4-76.3 times lower than radon acceptable level of Mongolian houses and apartments.*

Conclusion. *We have determined dose rate and effective equivalent dose in Gurvanbulag, Khairkhan, Dulaan-Uul, Zuuvch Ovoo uranium deposits in Mongolia. Also we compared radioactivity in soil, water, animal milk, air samples in these deposits. Depending on soil structure in some points were high dose rate and effective equivalent dose. In most points around uranium deposits dose rate and effective equivalent dose were in the range of worldwide mean value. This research will play important role for determination radiation monitoring around uranium deposits of Mongolia before beginning uranium mine. Conventional resources of uranium in Mongolia ready for mining are Khairkhan, Kharaat, Gurvanbulag, Dornod Uran, Dulaan-Uul(Dimović et al. 2020).*

Keywords: *Specific activity, gamma spectrometer, uranium deposit*

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I. Introduction

Uranium is a Natural Occurring Radioactive Materials (NORM) which is widely distributed within the earth's crust and defined as Low Specific Activity material. The element has wide spectrum of applications in various fields and plays an important role in human life by supplying electrical energy and it is the basic mineral used in the production of nuclear energy(Mathuthu, Uushona, and Indongo 2021). Almost all uranium is found in nature as the isotope ^{238U}. Uranium can be found in minute quantities in igneous, metamorphic, or sedimentary rocks, soils, and in waters including terrestrial and ocean waters, and easily oxidized to form a number of common uranium oxides(Balaram, Rani, and Rathore 2022). It undergoes radioactive decay into a series of 13 radionuclides before reaching the stable ^{206}Pb. This radionuclide emit alpha or beta radiation and some also emit gamma radiation of widely varying energies(Sánchez-González et al. 2014). Most of uranium mining and milling waste materials were deposited on surface and have been exposed to weathering for many years(Fernando P. Carvalho, Oliveira, and Malta 2014a). Radiological exposure of humans to radionuclides from uranium mining and milling waste depends upon the environmental dispersion of uranium waste and radionuclide transfer pathways. These pathways include the transfer of radionuclides from uranium waste to soils and from soils to plants, and then radionuclide ingestion with the diet of local populations(Fernando P. Carvalho, Oliveira, and Malta 2014b). Almost all uranium is found in nature as the isotope ^{238}U. It undergoes radioactive decay into a series of 13 radionuclides before reaching the stable ^{206}Pb. This radionuclide emit alpha or beta radiation and some also emit gamma radiation of widely varying energies(Sánchez-González et al. 2014). The understanding of the transfer of elements and radionuclides in ecosystems is essential in order to assess risks from radioactive releases into the environment(Roivainen et al. 2022). Human exposure to environmental uranium has long been considered a radiological health risk, although there are few epidemiological studies that have been able to demonstrate resultant harm, even in occupational contexts(Smedley and Kinniburgh 2023). The International Atomic Energy Agency (IAEA) recommends member countries to use Radiological Environmental Impact Assessment (REIA) to identify mitigation method to protect the environment against ionizing radiation(Goulet et al. 2022). Knowing the baseline level of radioactivity in areas naturally enriched in radionuclides is important in the uranium mining context to assess radiation doses to humans and the environment both during and after mining(Raghavendra et al. 2014). As the foundation of nuclear energy, uranium mining and metallurgy (UMM) is facing new developing opportunities as well as challenges from stricter radiation safety management(Zhang et al. 2022). Radioactivity exposure pathways of humans include external radiation, inhalation of radon and dust, and ingestion of radionuclides with the diet. In uranium mining and milling areas the existence of spoil heaps and mine drainage into water streams, may easily lead to accumulation of uranium series radionuclides in vegetables and other agriculture products, thus entering the food chain(F.P. Carvalho, Oliveira, and Malta 2014). From the ingestion of foodstuff, the potassium ingested by us contains 0.0117% of radioactive ^{40}K which decays and imparts beta and gamma energy to the human body. For example 140 g of potassium in a normal male contains 0.0165 g of ^{40}K that decays and emits radiation in our bodies equivalent to 4400 Bq(Baloch et al. 2012). The fine mineral slag produced in the process of uranium mining and milling is called uranium tailings which contain natural long-life radionuclides such as ^{238}U, ^{226}Ra, ^{232}Th, ^{40}K and some heavy metals associated with uranium mines(Yong et al. 2021). Recognition of these problems led to the development of uranium mining regulations in various countries with standards that limit the quantity of hazardous materials released into the environment. In most regulations, under normal mining operations, the radiological effective dose limit of 20 mSv/y for occupational exposures and 1 mSv/y for nonradiation worker exposures have been adopted as recommended by the International Commission on Radiological Protection(Lolila and Mazunga 2023). For any gamma-ray survey made over land, a principal component of the naturally occurring radiological background comes from rocks and soils because earth materials inevitably contain some level of radionuclides, in particular potassium-40 (^{40}K), uranium-238 (^{238}U), thorium-232(^{232}Th) and their short lived daughter products(Marsac et al. 2016). Especially, uranium mining contaminates the environment by means of abandoned waste containing radioactive material. So, this element is one of the most widespread contaminants in soils and groundwater around to mining areas(Sánchez-González et al. 2014). Because of its high solubility in water, radon is always present in underground and mineral water, and it gets into the human system by either ingestion or inhalation, which, in either case, causes significant radiological damage to the exposed body tissue or organ. When radon diffuses in air, it gets attached to the lungs and emits very short-lived alpha particle emitting progenies (^{210}Po and ^{214}Po) which inclined themselves at the thin wall of the lungs' epithelial tissues and emit radiation with a high linear energy transfer(Muhammad, Ismail, and Garba 2022).

Three biggest Mongolian uranium deposits are named Mardai, Gurvanbulag and Dornod, which are located at the territory of Dashbalbar town of Dornod province. Nowadays, Chinese Nuclear Energy corporation is engaged Mardai, Gurvanbulag uranium deposits. Gurvanbulag uranium deposit is taken second place by uranium resource in Mongolia. It has about 20000 ton uranium resource. As they said that will began uranium mining in 2015. In 1971 it was began uranium exploration in uranium deposits which are located Bayandun,

Gurvanbulag and Dashbalbar towns of Dornod province. In 1974 it was discovered uranium deposits there and in 23 Dec. 1981 there have made contract between Russian and Mongolian governments about using uranium deposits in Mongolia. Under this contract in 1988- 1995 there were explored 501.6 ton of uranium ore.(Erkhembayar, Tumendemberel, et al. 2013)

By the number of uranium reserves, today Mongolia is among the 10 richest countries in the world. According to recent geological studies a proven uranium reserve in Mongolia is 1.475 million tons(Mohammedi et al. 2021). Radionuclides have been present always in every environment of the earth's surface. Natural background radiation exposure is mainly caused by primordial radioactivity and cosmic radiation. Primordial radioactivity is mainly due to the presence of 238U, 232Th series radionuclides and 40K in the earth's crust. Cosmic radiation comes through the earth's atmosphere, from the sun and galaxies. The primary cosmic radiation interacts with the atmospheric matter and produces Cosmo genic radionuclides also known as secondary cosmic radiation. The Zoovch Ovoo roll-front deposit 130 kilometres south of Sainshand at Ulaanbadrah Soum has 67,700tU as 'reserves' at 0.02 to 0.04% according to Monatom, amenable to ISL. Areva's resource figures are tabulated above. It was discovered in 2011, and Cogegobi is undertaking a prefeasibility study with a view to production from Zooch Ovoo by ISL at about 2000 tU/yr. ISL testing continues into 2017. On the Dulaan Uul roll-front deposit 20 kilometres west of Zoovch Ovoo, Cogegobi has been trialling ISL at Umnut and Monatom quotes an inferred resource of 11,800 tU at 0.015%. It was discovered in 2007(Altankhuyag, Baatartsogt, and Munkhtur 2019). In the Mongolia, Zuuvch ovoo was largest uranium deposit and it has 67,706 tonnes. In-situ recovery (ISR) was the method considered for mining the Zuuvch Ovoo uranium deposits(Purevsuren and Kim 2019). Currently, no uranium can be produced in Mongolian facilities except pilot testing being done first. A pilot test was carried out at the Khairhan and Kharaat deposits in Mongolia and these experiments have demonstrated the ore to be amenable to acid leach (sulphuric acid) with the addition of an oxidizing agent. These tests confirmed that hydraulic control can be maintained and that the uranium solubilization and mobilization can be controlled. The results of the test were encouraging, with the well production rate, uranium concentration in produced solutions, chemical usage, and estimated uranium recovery all within ranges expected for normal commercial operations. There are a number of Mongolian uranium deposits are in the stage of mine development. The Government of Mongolia has approved the agreement of mine development of the Zuuvch ovoo and Dulaan uul deposits. Pilot testing on these deposits is underway and uranium will be extracted by in-situ leaching soon.(Altankhuyag, Baatartsogt, and Munkhtur 2019)

Mongolia has 13 uranium deposits, among them in four biggest deposits first time we have determined radiation background. Also we have determined a radioactivity in soil, water, animal milk and air samples in Gurvanbulag, Khairkhan, Dulaan-Uul, Zuuvch Ovoo uranium deposits and compared these values with world data.

II. Methodology

There were collected soil samples with 10*10 square cm, depth 5cm, which is collected from some points of Gurvanbulag, Dulaan-Uul , Zuuvch Ovoo, Khairkhan uranium deposits in Mongolia. For determination of natural and artificial radioactivity and dose rate was used gamma ray spectrometer. Samples were put into 700cm^3 volume of Marinelli vessel and measured for one hour by gamma ray spectrometer with semiconductor detector. There were determined the specific radioactivity of isotope in a soil by full assimilation square following the standard **MNS 5626:2006.**

The specific radioactivity of isotope in a soil samples was determined by following equation. (Erkhembayar and Chimedtsogzol n.d.)

$$A_i = \frac{N(E_i) - \Phi(E_i)}{t \cdot k \cdot \varepsilon_0(E) \cdot k_\gamma \cdot m} \quad (1)$$

Where: A_i - specific radioactivity of isotope (Bq/kg);
N(E)-spectral line square,
$\Phi(E_i)$- radioactive background,
$\varepsilon_0(E)$ – absolute efficiency(ρ=1g/cm^3) for water,
k- gamma ray relaxation constant in a sample,
k_γ- ascent of gamma quantum,
m -sample mass (kg),
t -measured time(s)

There was used a detector efficiency using standard solutions with many isotopes, which was prepared in California of USA in 1994 and Amersham group of Germany in 1996. The specific radioactivity of the ^{226}Ra isotope in a soil sample was determined very powerful 609.31 keV (^{214}Bi) line. There was determined percentage of 186,21 keV line square in total line square of 186 keV of ^{235}U ба ^{226}Ra and was examined equivalency between uranium and radium.

For determination of **t**he specific radioactivity **^{232}Th** – were registered gamma rays with energies **583,19 keV (^{208}Tl), 911,16 keV (^{228}Ac).** So for determination of **t**he specific radioactivity of ^{238}U, ^{232}Th, ^{226}Ra were used several lines respectively and it increased experiment belief.

The specific radioactivity of **^{40}K, ^{137}Cs** isotopes were determined **1460,75 keV, 661.66 keV** gamma ray lines.(Garg 2016)

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 (Erkhembayar, Ulaanbaatar, et al. 2013):

$$P_{abs} = 0,427A_U + 0,662A_{Th} + 0.043A_K \quad (2)$$

Where: $A_{Ra}, A_{Th}, A_K -$ Ra-226, Th-232, K-40 - the specific activity (Bq/kg); P_{abs} – is the absorbed dose rate (nGy.h^{-1}), A_{Ra}, A_{Th} and A_K are the activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K in Bq.kg^{-1}, respectively. From this value, annual effective dose in mSv.a^{-1} was calculated by the following formula(UNSCEAR 2000).

$$P_{abs} = D\ (nGy.h^{-1}) \times 24 \times 365 \times 0.2 \times 0.7 \times 10^{-6} \quad (3)$$

There was determined the radiation background around uranium deposits in Mongolia and compared these results with world mean value. Results were shown in figures.

III. Results and discussion

I. **Radiation background around uranium deposits of Mongolia**

Using soil radioactivity, we have determined dose rate and effective equivalent dose around some uranium deposits in Mongolia and compared them with world data(Erkhembayar, Tumendemberel, et al. 2013).

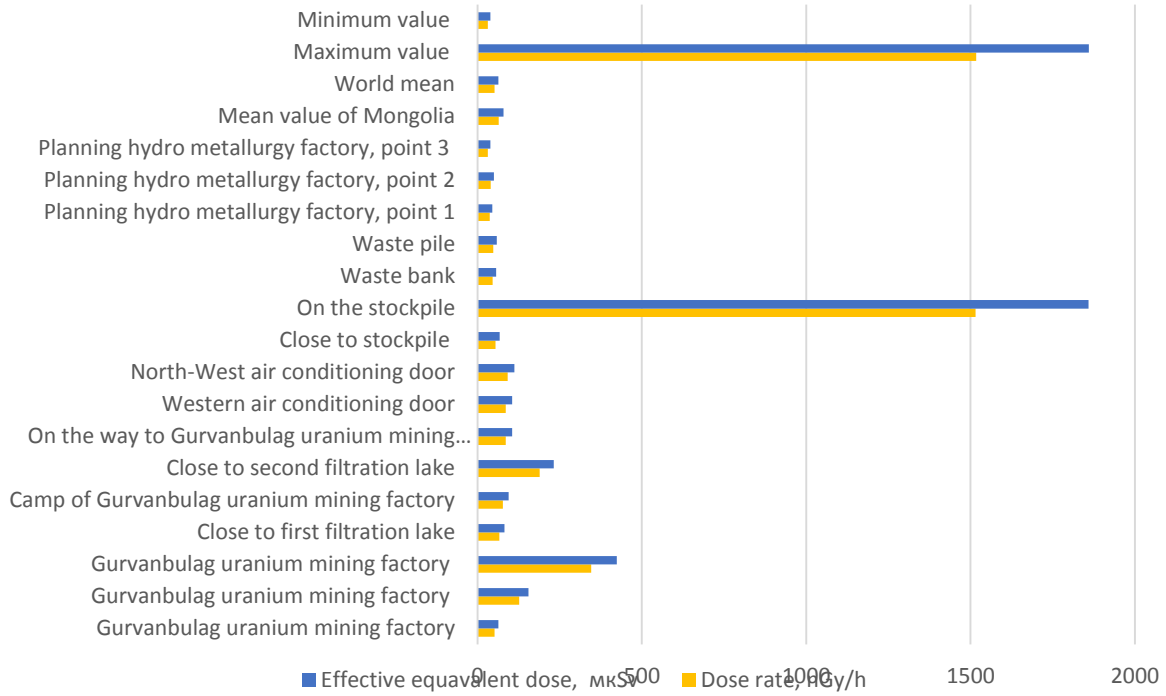

Figure 1. Dose rate and effective equivalent dose in of Gurvanbulag uranium deposits in Bayandun town of Dornod province, Mongolia(Erkhembayar, Tumendemberel, et al. 2013)

Maximum value of Gurvanbulag uranium deposit dose rate in Bayandun town of Dornod province was 1516.9 nGy/h, which was 29.27 times higher than world mean. Minimum value of dose rate was 31.5 nGy/h, which was 1.65 times lower than world mean. Maximum value of effective equivalent dose was 1860.3 µSv, which was 29.2 times higher than world mean. Minimum value of effective dose rate was 38.6 µSv, which was 1.65 times lower than world mean.

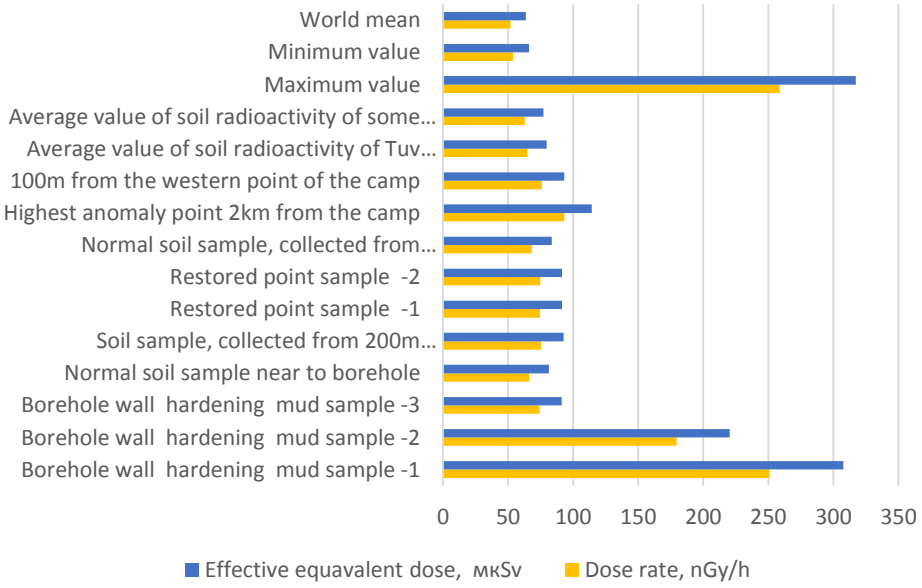

Figure 2. Dose rate and effective equivalent dose around Dulaan-Uul uranium camp of Dornogovi province of Mongolia(Enkhbat et al. 2009)

Maximum value of Dulaan-Uul uranium deposit dose rate in Ulaanbadrakh town of Dornogovi province was 258.7 nGy/h, which was 10.16 times higher than world mean. Minimum value of dose rate was 53.9 nGy/h, which was in the range of world mean. Maximum value of effective equivalent dose was 317.3 µSv, which was 4.97 times higher than world mean. Minimum value of effective dose rate was 66.1 µSv, which was in the range of world mean.

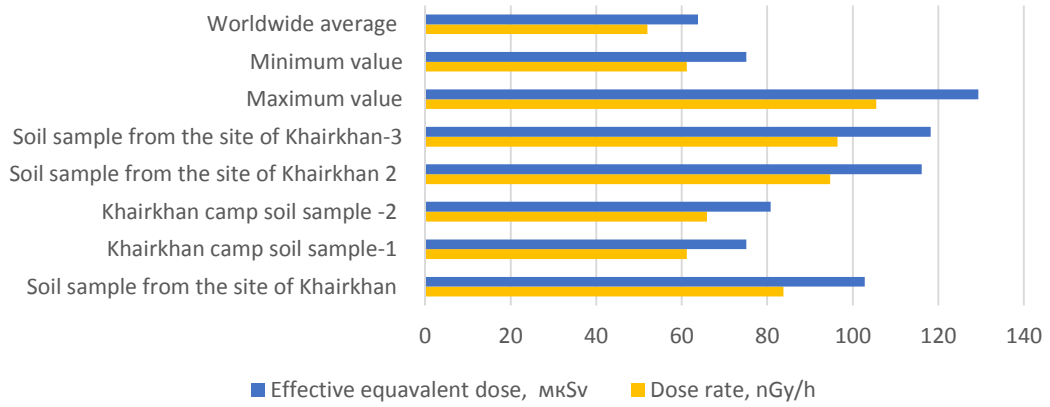

Figure 3. Dose rate and effective equivalent dose of uranium deposit Khairkhan uranium deposit of Dornogovi province in Mongolia(Enkhbat et al. 2009)

Maximum value of Khairkhan uranium deposit dose rate in Dornogovi province was 105.5 nGy/h, which was 2.02 times higher than world mean. Minimum value of dose rate was 61.2 nGy/h, which was 1.12 times higher than world mean. Maximum value of effective equivalent dose was 129.4 µSv, which was 2.02 times higher than world mean. Minimum value of effective dose rate was 75.07 µSv, which was 1.17 times higher than world mean.

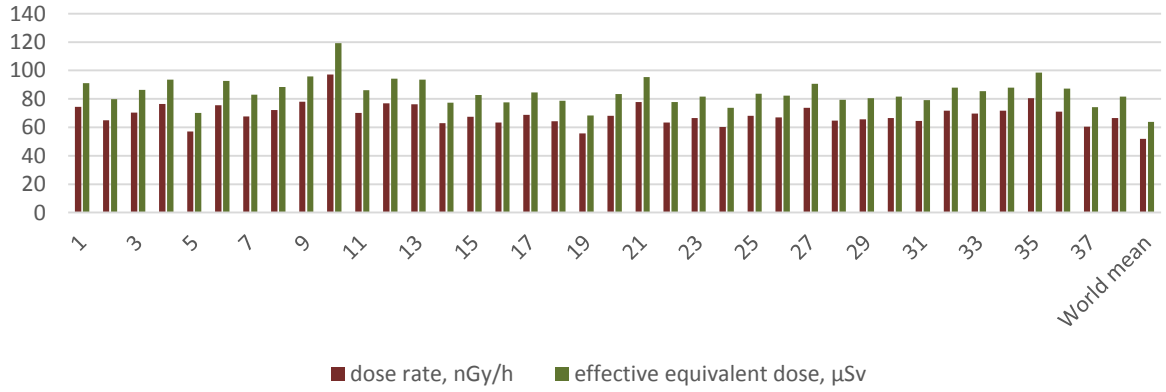

Figure 4. Dose rate and effective equivalent dose of uranium deposit Zuuvch Ovoo uranium deposit of Dornogovi province in Mongolia.

At the point 10 dose rate in Zuuvch Ovoo uranium deposit of Dornogovi province was 97.2 nGy/h, effective equivalent dose was 119.2 µSv, which was 1.9 times higher than world mean value. These were highest values in this area. In point 19, dose rate was 55.7 nGy/h, effective equivalent dose was 68.4 µSv, which was 1.07 times higher than world mean value.

II. Water and animal milk radioactivity around uranium deposits

For determination of the radon in water was used HP-Ge gamma-spectrometer. Water samples were put in one liter volume Marinelli vessel and measured water radioactivity for one hour. For determination of radon radioactivity in water were used 609.31 keV, 295.21 keV energy gamma ray lines, which were ^{214}Pb decay products and 351.92 keV energy gamma ray lines, which were ^{214}Bi decay products.

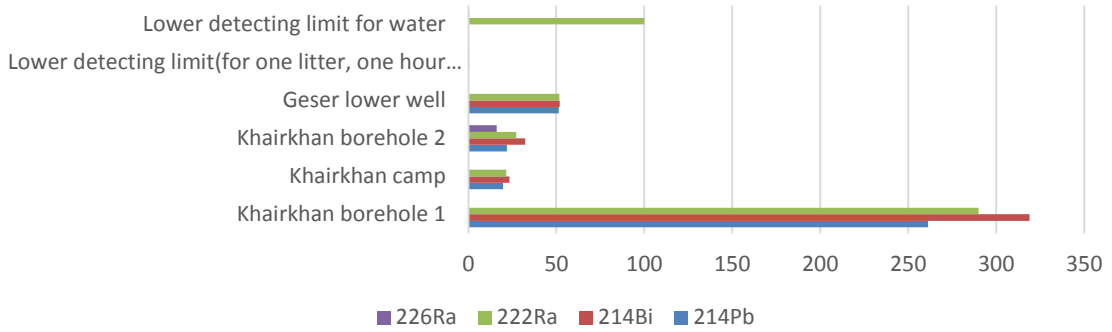

Figure 5. Water radioactivity near Khairkhan deposit, Bq/l

In sample of Khairkhan borehole point 1, water radioactivity was very high. In other points water radioactivity was 6-8 times lower than Khairkhan borehole 1.

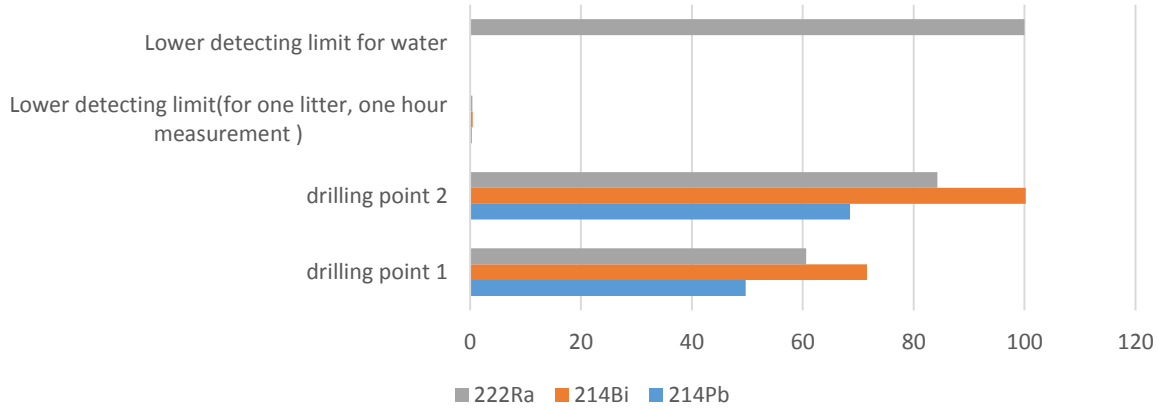

Figure 6. Water radioactivity near Khairkhan deposit, Bq/l

In drilling point 2 sample volume radioactivity of radioactive elements was higher than drilling point 1 sample.

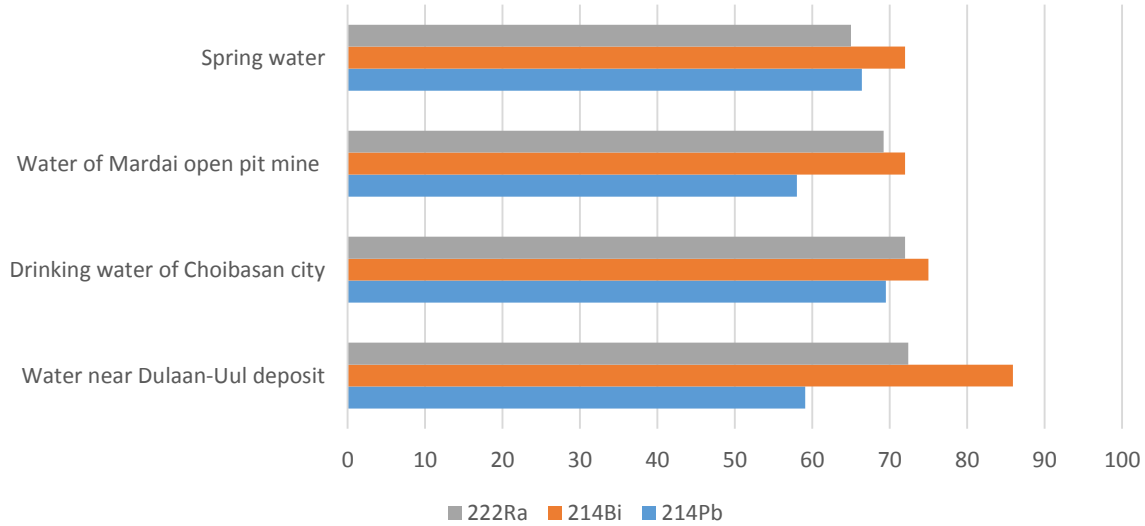

Figure 7. Compared water radioactivity near uranium deposit, Bq/l

^{214}Bi volume radioactivity in Dulaan-Uul uranium deposit was 1.19 times higher than spring water sample. In other samples volume radioactivity of elements was lower or comparable with spring water sample.

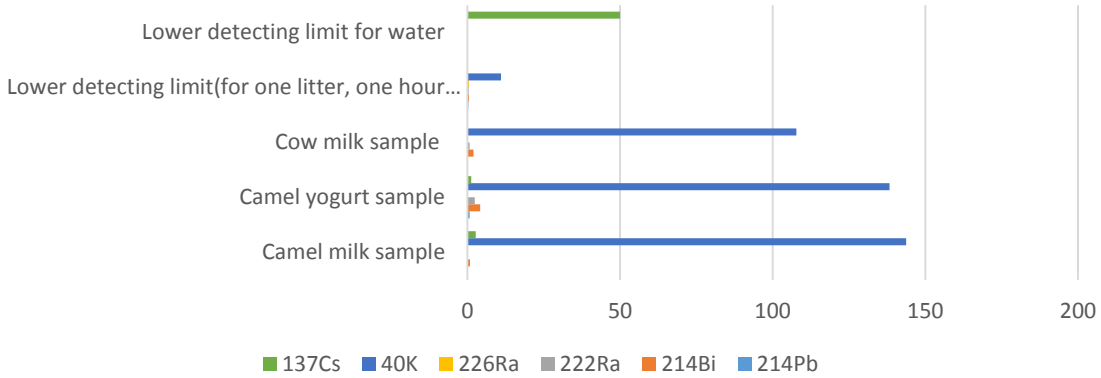

Figure 8. Animal milk radioactivity near Dulaan-Uul uranium deposit, Bq/l

In figure 8 we can see that radioactive isotopes ^{214}Pb, ^{214}Bi, ^{222}Rn, ^{222}Ra in camel and cow milk were in the range of lower limit of detection, but 137Cs camel and cow milk, camel yogurt was 18.5-38.5 times lower than acceptable level.

III**. Radon volume radioactivity around uranium deposits**

For determination radon amount around Gurvanbulag uranium deposit was used TM372 Sample counter. There was used PCXR4 Universal Sample Pump, which pumps 2 liter air in one minute, was run in 5 minutes. After 7 minutes were detected alpha particles in 3 minutes.

Radioactivity measurement in working area of Gurvanbulag uranium deposit, Bq/m3				
	Po-218	**Pb-214**	**Bi-214**	**Rn-222**
Air shed (August 29th, 2006)	4,7	4,3	4,1	4,3
Airs hed (August 26th, 2006)	3,5	3,6	3,4	3,5
Housing for miners, office 1 (August 30th, 2006)	7,1	1,6	0,5	1,8
Housing for miners, office 2 (August 30th, 2006)	7,1	1,8	0,6	1,9
Housing for miners, office 3 (August 30th, 2006)	7,7	2,1	0,9	2,2
Housing for miners, new office 1 (August 31st, 2006)	0,6	2,8	3,2	2,7
Housing for miners, new office 2 (August 31st, 2006)	1,2	2,4	2,5	2,3
New camp, office (September 23, 2006)	4,7	2,7	2,2	2,7
New camp, dining hall (Sept 23, 2006)	4,1	1,3	0,7	1,4
New camp, dining hall (Sept 28, 2006)	3,5	1,9	1,5	2,0
New camp, office (Oct 10, 2006)	27.7	31.4	31	30.9
Air shed (Sept 29, 2006)	4,1	0,7	0,0	0,8
Radon acceptable level in a house, apartment of Mongolia, MNS 5627:2006				100
Radon acceptable level in a radiation area of Mongolia, MNS 5627:2007				1110

Table 1. Radioactivity measurement in working area of Gurvanbulag uranium deposit, Bq/m3

Radon in houses of miners around Gurvanbulag uranium deposit was 3.2-71.4 times lower than acceptable level in a house, apartment of Mongolia.

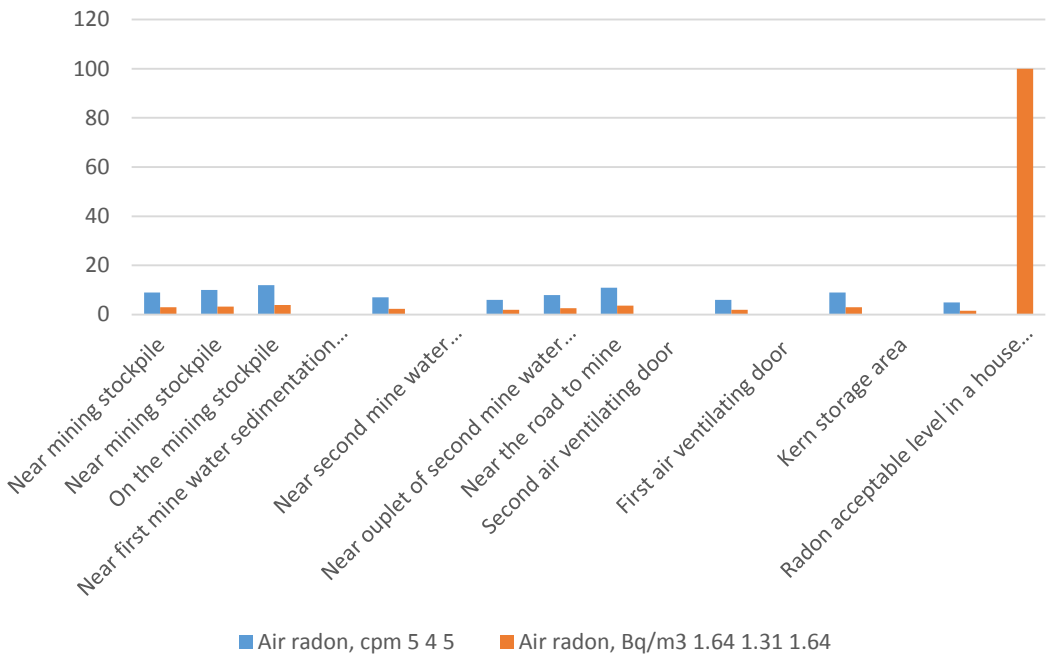

Figure 9. Radon measurement in open field area of Gurvanbulag uranium deposit, Bq/m3

Radon volume radioactivity in the open field area was 25.4-76.3 times lower than radon acceptable level of Mongolian houses and apartments.

References

[1]. Altankhuyag, Dorjyunden, Baldorj Baatartsogt, and Batbold Munkhtur. 2019. "Uranium Deposits of Mongolia, Their Exploration and Mine Development." Mongolian Geoscientist (49): 50–57.

[2]. Balaram, V., A. Rani, and D.P.S. Rathore. 2022. "Uranium in Groundwater in Parts of India and World: A Comprehensive Review of Sources, Impact to the Environment and Human Health, Analytical Techniques, and Mitigation Technologies." Geosystems and Geoenvironment 1(2): 100043. https://doi.org/10.1016/j.geogeo.2022.100043.

[3]. Baloch, Muzahir Ali et al. 2012. "A Study on Natural Radioactivity in Khewra Salt Mines, Pakistan." Journal of Radiation Research 53(3): 411–21.

[4]. Carvalho, F.P., J.M. Oliveira, and M. Malta. 2014. "Intake of Radionuclides with the Diet in Uranium Mining Areas." Procedia Earth and Planetary Science 8: 43–47. http://dx.doi.org/10.1016/j.proeps.2014.05.010.

[5]. Carvalho, Fernando P., João M. Oliveira, and Margarida Malta. 2014a. "Radioactivity in Iberian Rivers with Uranium Mining Activities in Their Catchment Areas." Procedia Earth and Planetary Science 8: 48–52. http://dx.doi.org/10.1016/j.proeps.2014.05.011.

[6]. ———. 2014b. "Radioactivity in Soils and Vegetables from Uranium Mining Regions." Procedia Earth and Planetary Science 8: 38–42. http://dx.doi.org/10.1016/j.proeps.2014.05.009.

[7]. Dimović, Slavko D. et al. 2020. "Assessment of Environmental Radioactivity and Health Hazard at Stara Planina Region." Nuclear Technology and Radiation Protection 35(4).

[8]. Enkhbat, N. et al. 2009. "Study of Natural Background Radiation around Gurvanbulag Uranium Deposit Area." In AIP Conference Proceedings,.

[9]. Erkhembayar, Ts, B. Tumendemberel, et al. 2013. "Radioactive Monitoring in Gurvanbulag Uranium Deposit of Domod Province in Mongolia." 8th International Forum on Strategic Technology 2013, IFOST 2013 - Proceedings 1: 526–28.

[10]. Erkhembayar, Ts, T. Ulaanbaatar, et al. 2013. "Soil, Coal and Ash Radioactivity around Baganuur Coal Deposit in Mongolia." 8th International Forum on Strategic Technology 2013, IFOST 2013 - Proceedings 1: 521–25.

[11]. Erkhembayar, Ts, and N Chimedtsogzol. "Soil , Coal and Ash Radioactivity and Human Health of Baganuur District in Ulaanbaatar City of Mongolia."

[12]. Garg. 2016. "International Journal of Computer International Journal of Computer." International Journal of Population Data Science 0(05): 5–6.

[13]. Goulet, Richard R. et al. 2022. "Best Practices for Predictions of Radionuclide Activity Concentrations and Total Absorbed Dose Rates to Freshwater Organisms Exposed to Uranium Mining/Milling." Journal of Environmental Radioactivity 244–245(January).

[14]. Lolila, Farida, and Mohamed S Mazunga. 2023. "Journal of Radiation Research and Applied Sciences Measurements of Natural Radioactivity and Evaluation of Radiation Hazard Indices in Soils around the Manyoni Uranium Deposit in Tanzania." Journal of Radiation Research and Applied Sciences 16(1): 100524. https://doi.org/10.1016/j.jrras.2023.100524.

[15]. Marsac, Kara E. et al. 2016. "Modeling Background Radiation Using Geochemical Data: A Case Study in and around Cameron, Arizona." Journal of Environmental Radioactivity 165: 68–85. http://dx.doi.org/10.1016/j.jenvrad.2016.07.012.

[16]. Mathuthu, Manny, Vera Uushona, and Vaino Indongo. 2021. "Radiological Safety of Groundwater around a Uranium Mine in Namibia." Physics and Chemistry of the Earth 122(July 2020): 102915. https://doi.org/10.1016/j.pce.2020.102915.

[17]. Mohammedi, Kamel et al. 2021. "History of Lower-Limb Complications and Risk of Cancer Death in People with Type 2 Diabetes." Cardiovascular Diabetology 20(1): 1–13. https://doi.org/10.1186/s12933-020-01198-y.

[18]. Muhammad, Abdu Nasiru, Aznan Fazli Ismail, and Nuraddeen Nasiru Garba. 2022. "Annual Effective Dose Associated with

Radioactivity in Drinking Water from Tin Mining Areas in North-Western Nigeria." Journal of Radiation Research and Applied Sciences 15(3): 96–102. https://doi.org/10.1016/j.jrras.2022.06.008.

[19]. Purevsuren, Boldsaikhan, and Juyoul Kim. 2019. "Assessment of Potential Health Risk to the Public around Uranium Mining in Mongolia." : 24–26.

[20]. Raghavendra, T. et al. 2014. "Assessment of Radon Concentration and External Gamma Radiation Level in the Environs of the Proposed Uranium Mine at Peddagattu and Seripally Regions, Andhra Pradesh, India." Journal of Radiation Research and Applied Sciences 7(3): 269–73. http://dx.doi.org/10.1016/j.jrras.2014.03.007.

[21]. Roivainen, Päivi et al. 2022. "Transfer of Elements into Boreal Forest Ants at a Former Uranium Mining Site." Environmental Pollution 304(March).

[22]. Sánchez-González, S., N. Curto, P. Caravantes, and A. García-Sánchez. 2014. "Natural Gamma Radiation and Uranium Distribution in Soils and Waters in the Agueda River Basin (Spain-Portugal)." Procedia Earth and Planetary Science 8: 93–97. http://dx.doi.org/10.1016/j.proeps.2014.05.019.

[23]. Smedley, P. L., and D. G. Kinniburgh. 2023. "Uranium in Natural Waters and the Environment: Distribution, Speciation and Impact." Applied Geochemistry 148(June 2022): 105534. https://doi.org/10.1016/j.apgeochem.2022.105534.

[24]. UNSCEAR. 2000. I United Nations Scientific Committe on the Effects of Atomic Radiation Sources and Effects of Ionizing Radiation Volume I: Source.

[25]. Yong, Jinlong et al. 2021. "Measurement and Spatial Distribution Pattern of Natural Radioactivity in a Uranium Tailings Pond in Northwest China." Journal of Radiation Research and Applied Sciences 14(1): 344–52. https://doi.org/10.1080/16878507.2021.1964314.

[26]. Zhang, Hui et al. 2022. "Delimiting Radiation Protection Distance of Underground Uranium Mining and Metallurgy Facilities: A Case Study in China." SSRN Electronic Journal 8(November): e12419. https://doi.org/10.1016/j.heliyon.2022.e12419.

Ts.Erkhembayar, et. al. "Radioactive background in some uranium deposits of Mongolia " *The International Journal of Engineering and Science (IJES)*, 12(12), (2023): pp. 29-38.