*Transactions of the Korean Nuclear Society Autumn Meeting*
*Goyang, Korea, October 24-25, 2019*

# Assessment of Potential Health Risk to the Public around Uranium Mining in Mongolia

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## 1. Introduction

Nuclear energy provided about 11% of the world's electricity from about 453 power reactors. About 57 more reactors were under construction, equivalent to about 15% of existing capacity by 2018 [1]. For these reactors fuel supply, over the 59,400 tonnes production of uranium ore were mined in 2017. Around 29,518 tonnes production of uranium extracted by in situ leaching (ISL) method. Kazakhstan, Canada, and Australia were the top three producers and together account for 70% of world uranium production. 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. The geological conditions necessary for mining by ISR were present in the Zuuvch Ovoo area. ISR might be the most economically efficient method of uranium extraction in Mongolia. Nonetheless, there were risks affiliated with ISR uranium mining. The goal of this study was to evaluate the health risk and radiation exposure from ISR uranium mine in Dornogobi, Mongolia.

## 2. Materials and Methods

The Zuuvch ovoo uranium site is located in south part of Zuunbayan town, Dornogobi province of Mongolia. Zuunbayan town is sparsely populated, with 2,364 inhabitants and 16,800 animals occupying on 1,468.76 square kilometers. Annual average precipitation is less than 230 mm and wind speed is 4-8 m/s. For the radiological environmental impact assessment, soil samples were collected from 30 different location within 500 $m^2$ at Zuuvch ovoo site in 2014. Depth of soil sampling is around 5 cm from the surface with 15cm x 15cm area. In Zuuvch Ovoo, groundwater moves slowly, between 1 and 10 meters per year. Considering these low velocities and the size of the basin, several thousand years may be necessary for the groundwater to reach the Uranium deposits.

Table I: The concentration of radionuclides (Bq/kg) in surface soil samples around the Zuuvch ovoo uranium site

| Soil samples | Activity of Isotopes (Bq/kg) | | | |
|---|---|---|---|---|
| | $^{226}Ra$ | $^{232}Th$ | $^{40}K$ | $^{137}Cs$ |
| ZT 1 | 15 | 13 | 1192 | 3 |
| ZT 2 | 23 | 18 | 1043 | <1 |
| ZT 3 | 12 | 14 | 1159 | <1 |
| ZT 4 | 30 | 27 | 880 | <1 |
| ZT 5 | 19 | 17 | 1118 | 4 |
| ZT 6 | 13 | 16 | 1204 | 3 |
| ZT 7 | 18 | 19 | 802 | 2 |
| ZT 8 | 19 | 12 | 1166 | 3 |
| ZT 9 | 14 | 12 | 883 | <1 |
| ZT 10 | 9 | 11 | 939 | <1 |
| ZT 11 | 11 | 8 | 987 | 2 |
| ZT 12 | 10 | 8 | 845 | 3 |
| ZT 13 | 15 | 18 | 764 | 4 |
| ZT 14 | 14 | 16 | 964 | 5 |
| ZT 15 | 6 | 8 | 910 | <1 |
| ZT 16 | 19 | 15 | 875 | 2 |
| ZT 17 | 15 | 18 | 892 | 4 |
| ZT 18 | 10 | 10 | 1061 | <1 |
| ZT 19 | 12 | 11 | 785 | 3 |
| ZT 20 | 9 | 9 | 764 | 3 |
| ZT 21 | 11 | 8 | 804 | 1.5 |
| ZT 22 | 10 | 13 | 846 | <1 |
| ZT 23 | 30 | 29 | 917 | <1 |
| ZT 24 | 17 | 14 | 1098 | 2 |
| ZT 25 | 14 | 16 | 865 | <1 |
| ZT 26 | 21 | 22 | 819 | 4 |
| ZT 27 | 22 | 26 | 802 | <1 |
| ZT 28 | 14 | 15 | 998 | 2 |
| ZT 29 | 19 | 20 | 854 | <1 |
| ZT 30 | 12 | 11 | 943 | 7 |
| Mean | 15 | 15 | 979 | 3 |
| World mean [3] | 35 | 30 | 400 | 9.1 |

RESRAD was developed by the Argonne National Laboratory under the U.S. Department of Energy and the U.S. Nuclear Regulatory Commission as a multifunctional tool to assist in developing criteria for evaluating human radiation doses and risks associated with exposure to radiological contamination. RESRAD allowed users to specify the features of their site and to predict the dose received by an individual at any time.

RESRAD off-site was computer code that was developed to estimate the radiological consequences to individuals located offsite area of primary contamination. It calculated the radiation dose predicted radionuclide concentrations in the environment. In this study, seven exposure pathways were considered in RESRAD off-site: radiation exposure from inhalation, external gamma, and ingestions of meat, milk, soil, plant and drinking water. By selecting the different pathways, RESRAD off-site could be determine exposure scenario. Pathways were further separated into water independent pathways, for which the dose depended upon the soil radionuclide concentrations, and water dependent pathways, for which the dose depended upon the radionuclide concentration in groundwater [1, 4]

## 3. Results and Discussion

TEDE from the Zuuvch ovoo uranium site for all of the pathways summed over a duration of 70 years were calculated as shown in Tables II. According to result of RESRAD, the maximum TEDE of 1.260E-03 mSv/yr was found at 12.8 years. The result showed no significant increase compared with a basic radiation dose limit value of 0.25 mSv/year. $^{40}K$ contributed the most to TEDE, while $^{226}Ra$, $^{232}Th$ and $^{137}Cs$ had lesser effect.

Table II: Total effective dose equivalent (mSv/year) uranium area for all the pathways summed over a duration of 70 years

| Year | Total Effective Dose Equivalent (mSv/Year) | | | | |
|---|---|---|---|---|---|
| | Nuclides | | | | Total |
| | $^{226}Ra$ | $^{232}Th$ | $^{40}K$ | $^{137}Cs$ | |
| 0 | 2.36E-04 | 1.67E-05 | 9.00E-04 | 1.87E-05 | 1.17E-03 |
| 1 | 2.36E-04 | 3.54E-05 | 8.90E-04 | 1.82E-05 | 1.18E-03 |
| 5 | 1.21E-04 | 2.35E-04 | 8.51E-04 | 1.66E-05 | 1.22E-03 |
| 10 | 2.33E-04 | 2.03E-04 | 8.05E-04 | 1.48E-05 | 1.26E-03 |
| 20 | 2.31E-04 | 2.79E-04 | 7.19E-04 | 1.18E-05 | 1.24E-03 |
| 30 | 2.28E-04 | 3.02E-04 | 6.43E-04 | 9.36E-06 | 1.18E-03 |
| 40 | 2.25E-04 | 3.09E-04 | 5.75E-04 | 7.44E-06 | 1.12E-03 |
| 50 | 2.22E-04 | 3.12E-04 | 5.14E-04 | 5.91E-06 | 1.05E-03 |
| 70 | 2.16E-04 | 3.13E-04 | 4.10E-04 | 3.74E-06 | 9.43E-04 |

In the water-independent pathways, most of the total effective dose equivalent was caused by external exposure, meat (water-independent) and followed by soil ingestion. Fig. 1 shows the radiation doses over a duration of 70 years following contamination [4].

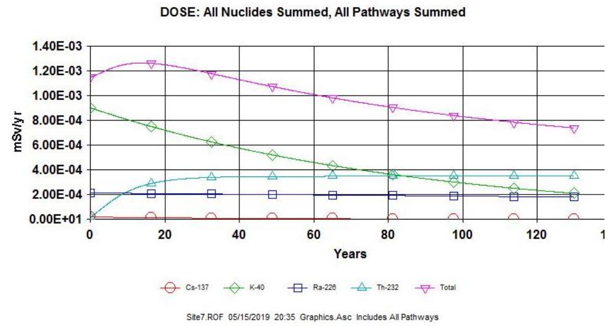


Fig. 1. Total effective dose equivalent from the all nuclides summed based on component pathways.

The results of cancer morbidity risk from the all nuclides $^{226}Ra$, $^{232}Th$, $^{40}K$ and $^{137}Cs$ based on component pathways were shown in Fig. 2. It was found that the cancer morbidity risks from exposure to $^{40}K$ was insignificantly greater than those from exposure to $^{232}Th$, $^{226}Ra$ and $^{137}Cs$. The assessed cancer morbidity risk for $^{40}K$ indicated a 4.10E-04 at 70 years.

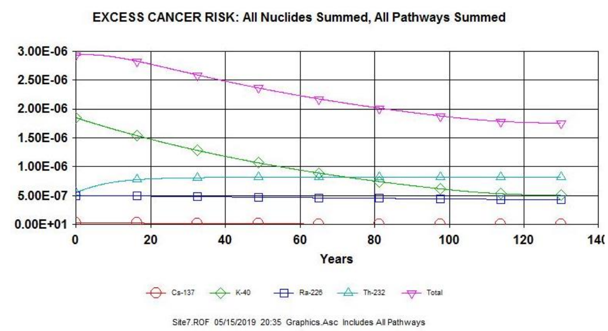


Fig. 2. Excess cancer morbidity risk from the all nuclides summed based on component pathways.

## 4. Conclusions

The aim of this study was to evaluate the health risk and radiation exposure from ISR uranium mine in Dornogobi, Mongolia using RESRAD. According to the result, maximum TEDE was 1.26E-03 mSv/year in 12.8 years which was less than basic radiation dose limit value. Therefore, radiological and cancer risks were not much considerable for the public who living near the uranium site.

## Acknowledgement

This research was supported by the 2019 Research Fund of the KEPCO International Nuclear Graduate School (KINGS), the Republic of Korea.

## References

[1] World nuclear performance report 2018, World nuclear association

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