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Radioactive levels and human health effects in a dumpsite on Ulaanbaatar city, Mongolia

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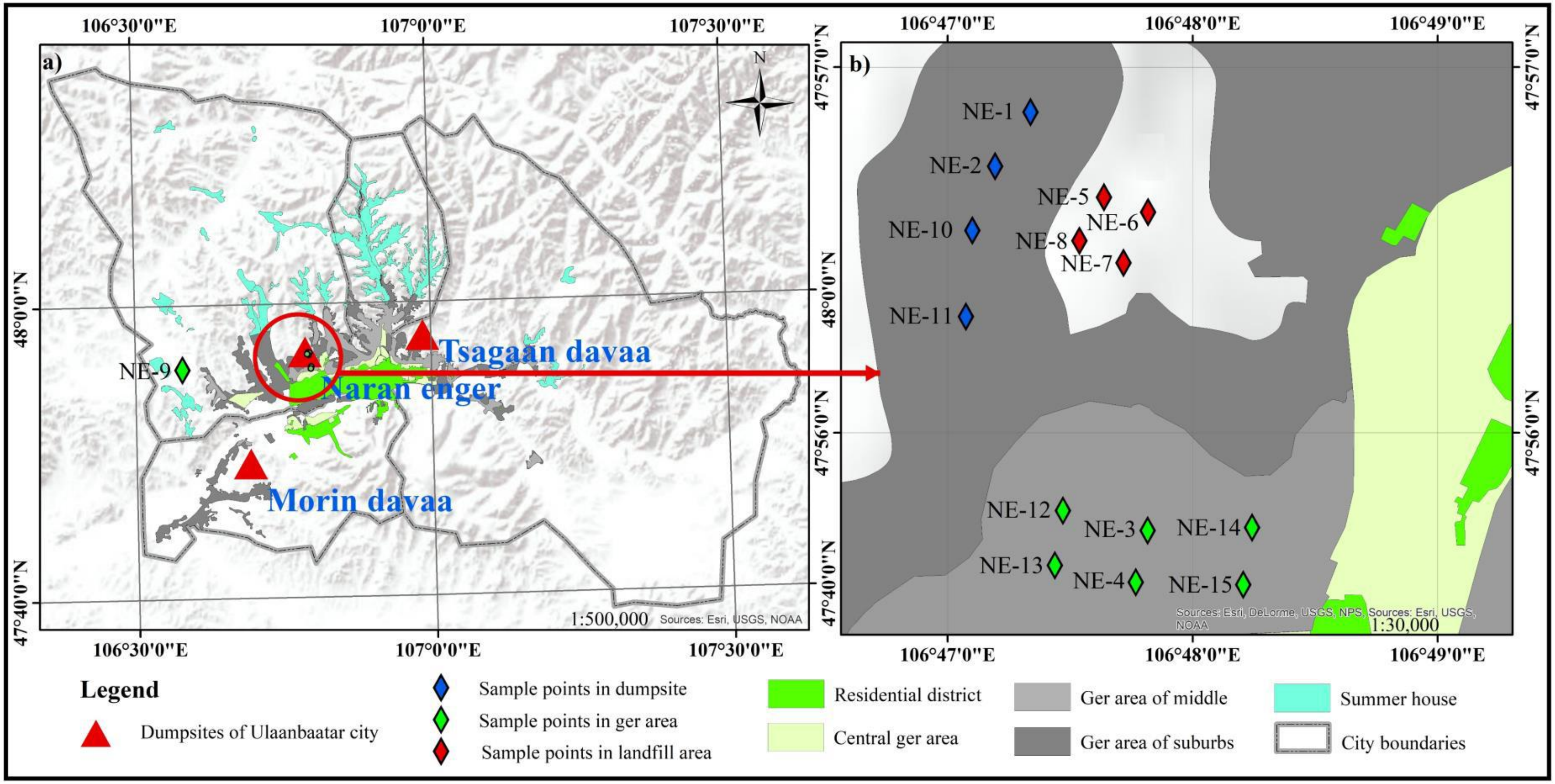
1. Introduction

Urban pollution has a significant negative impact on the health of the population and the socio-economy (Wang and You, 2021). Ulaanbaatar is located in central Mongolia and is the most important region in the country (Dorjsuren et al., 2021).



1. Introduction

Soil radioactivity is one of the main factors involved in the pollution of air, soil and water habitats. It is important to estimate the natural radioactivity level in soils and rock to evaluate the terrestrial gamma dose rate for outdoor environments (Mehra et al., 2007).

Table 1. Radioactive level of natural radioactive element in the soil (Bq kg^{-1}) of Ulaanbaatar

City and town	Radioactive elements		
	^{40}K	^{238}U	^{232}Th
Ulaanbaatar (40 point)	880±55	33 ± 9	39± 7
Average of 19 town	835	28	32
World Average	370	25	25

1. Introduction

Table 2 is a comparison of different specific activy of isotopes including 238U, 232Th, and 40K in soils between Ulaanbaatar, China, Japan, America and average value across the world. The specific activity of 238U in Ulaanbaatar is between 1.1 and 1.8 times higher than the average value across Earth; likewise, the activation percent of 232Th is 1.1 to 2.7 times higher and 40K is from 1.2 to 2.4 times higher (Table 2).

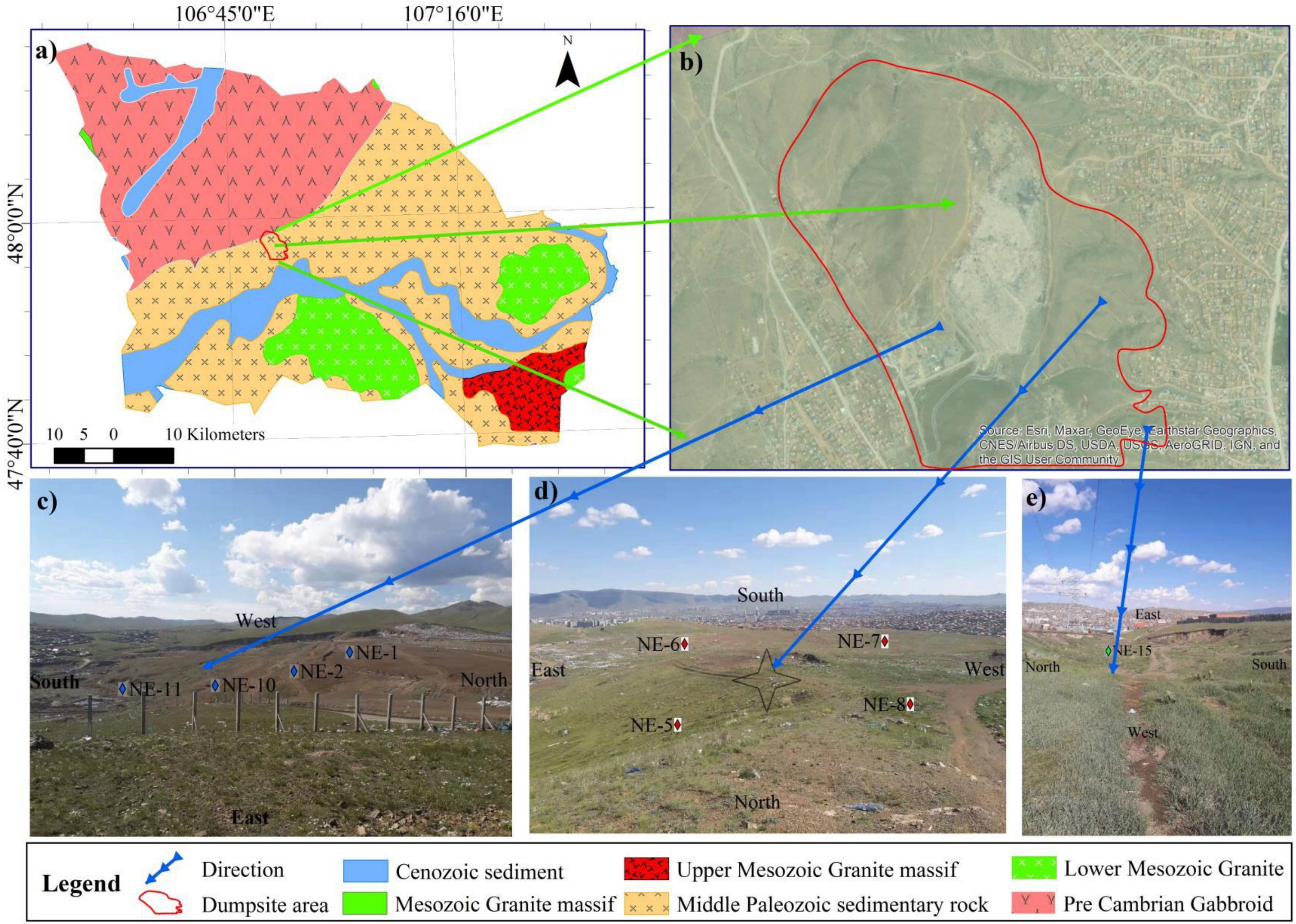
Table 2. Comparison of radioactivity levels in selected countries with those of Ulaanbaatar

Country, urban	Specific Activity Bq kg^{-1}		
	^{238}U	^{232}Th	^{40}K
Ulaanbaatar, Mongolia	33	39	880
Japan	15.9	22.5	443
China	40	49	580
United States of America	35	35	370
World Average	25	25	370

1. Introduction

Purpose of this research, to quantify the soil radioactivity element and radioactive isotopes and applied the hazard index to determine the around landfill.

2. Materials and Methods.



Results and Discussion

Table 3. Activation of natural and studied radioactivity isotope

Sample code	Specific Activity Bq kg^{-1}			
	^{226}Ra	^{232}Th	^{40}K	^{137}Cs
NE - 1	20	25	658	<1.1
NE - 2	18	21	629	<1.1
NE - 3	21	18	700	3
NE - 4	19	21	716	4
NE - 5	25	23	701	<1.1
NE - 6	19	14	393	<1.1
NE - 7	32	12	498	<1.1
NE - 8	13	34	843	<1.1
NE - 9	30	30	885	<1.1
NE - 10	24	25	679	<1.1
NE - 11	24	31	916	<1.1
NE - 12	25	27	875	<1.1
NE - 13	35	23	701	<1.1
NE - 14	26	28	967	<1.1
NE - 15	46	35	1136	<1.1
Reference site	13	13	650	<1.1
Average of area	24	24	747	<1.1
Minimum	13	12	393	<1.1
Maximum	46	35	1136	4
Ash	129	59	1626	<1.1
S.D	34.9	13.9	334.2	-
Median	19.5	21	679	-

Results and Discussion

$$Ra_{eq} = A_{Ra} + 10/7 A_{Th} + 10/130 A_k \quad (1)$$

$$H_{ex} = A_{Ra}/370 + A_{Th}/259 + A_k/4810 \quad (2)$$

$$H_{in} = A_{Ra}/185 + A_{Th}/259 + A_k/4810 \quad (3)$$

$$D_{outdoor} = (4.27 * C_{Ra} + 6.62 * C_{Th} + 0.43 C_k) * 0.01 \quad (4)$$

$$D_{indoor} = D_{outdoor} * 1.2 \quad (5)$$

$$ELCR = (E_{in} + E_{out}) * LE * RF \quad (6)$$

$$N_t = N_0 e^{-\lambda t} \quad (7)$$

Results and Discussion

Table 4. Radium equivalent activity, Indoor and outdoor radiation indices, Excess life-time cancer risk

Sample code	Specific Activity (Bq kg^{-1})			Radium equivalent activity (Bq kg^{-1})	External Hazard index		Absorbed Dose Rate ($nGy \cdot h^{-1}$)		Annual effective Dose ($mSv \cdot y^{-1}$)		Excess Life-time Cancer Risk ($*10^{-3}$)
	^{226}Ra	^{232}Th	^{40}K		H_{ex}	H_{in}	$D_{outdoor}$	D_{indoor}	$E_{outdoor}$	$E_{outdoor}$	
NE-1	20	25	658	106.33	0.29	0.34	53.38	64.06	0.07	0.37	1.30
NE-2	18	21	629	96.38	0.26	0.31	48.64	58.36	0.06	0.33	1.18
NE-3	21	18	700	100.56	0.27	0.33	50.98	61.18	0.06	0.35	1.24
NE-4	19	21	716	104.08	0.28	0.33	52.80	63.36	0.06	0.36	1.28
NE-5	25	23	701	111.78	0.30	0.37	56.04	67.25	0.07	0.39	1.36
NE-6	19	14	393	69.23	0.19	0.24	34.28	41.14	0.04	0.24	0.83
NE-7	32	12	498	87.45	0.24	0.32	43.02	51.63	0.05	0.30	1.05
NE-8	13	34	843	126.42	0.34	0.38	64.31	77.17	0.08	0.44	1.56
NE-9	30	30	885	141.04	0.38	0.46	70.72	84.87	0.08	0.64	1.2
NE-10	24	25	679	112.03	0.3	0.36	55.99	67.19	0.06	0.51	1.04
NE-11	24	31	916	138.86	0.37	0.44	70.15	84.19	0.08	0.64	1.1
NE-12	25	27	875	130.98	0.35	0.42	66.17	79.4	0.07	0.6	1.06
NE-13	35	23	701	121.86	0.32	0.42	60.31	72.37	0.07	0.56	1.19
NE-14	26	28	967	140.49	0.37	0.45	71.21	85.46	0.08	0.65	1.24
NE-15	46	35	1136	183.52	0.49	0.62	91.66	109.92	0.11	0.84	1.58
Reference site	13	13	650	81.57	0.22	0.26	42.11	50.53	0.05	0.29	1.02
Average	24	24	747	115.79	0.31	0.38	58.24	69.88	0.07	0.47	1.20
Min	13	12	393	69.23	0.19	0.24	34.28	41.14	0.04	0.24	0.83
Max	46	35	1136	183.52	0.49	0.62	91.66	109.92	0.11	0.84	1.58
Ash	129	59	1626	338.36	0.91	1.26	164.06	196.87	0.2	1.13	3.99
S.D	6	7	139	16.9	0	0	8.9	10.7	0	0.1	0.2
median	20	21	679	102.32	0.28	0.33	51.89	62.27	0.06	0.36	1.26
World average	25	25	370	370	1	1	57	84	0.07	0.34	$1.45*10^{-3}$

Results and Discussion

The strongest relationship was between a radium equivalent activity and the excess lifetime cancer risk (Fig. 3).

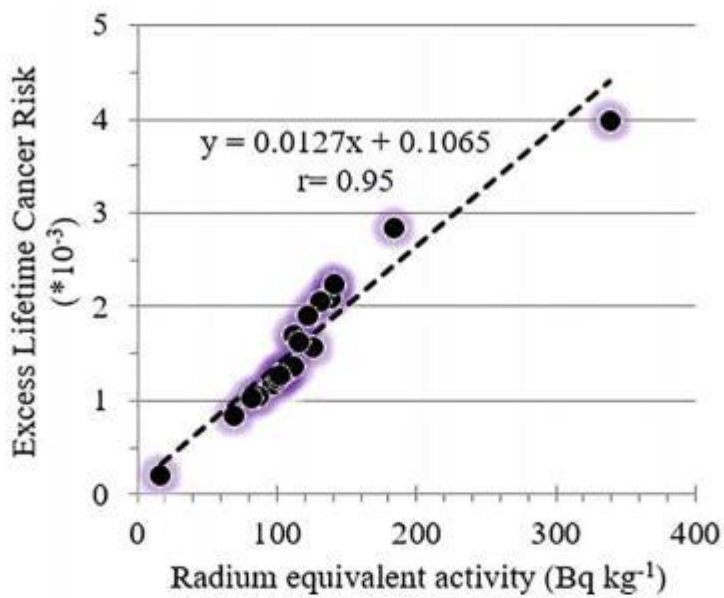


Fig. 3. Correlation between radium equivalent activity and excess lifetime cancer risk.

Results and Discussion

The radionuclide's fallout results show relatively little change. All samples measured at the dumpsite have high levels of radioactive isotopes, indicating that the waste content at the dumpsite has a strong impact.

Table 6. Radionuclide fallout and calculation results

	Specific activity ($Bq \cdot kg^{-1}$)								
	^{226}Ra			^{232}Th			^{40}K		
Sample code	Measurement results	Radionuclide fallout	Calculation results	Measurement results	Radionuclide's fallout	Calculation results	Measurement results	Radionuclide fallout	Calculation results
Average site conditions	24	0.98	23.01	24	1.00	23.00	747	1.00	746.00
Min	13	0.98	12.01	12	1.00	11.00	393	1.00	392.00
Max	46	0.98	45.01	35	1.00	34.00	1,136	1.00	1,135.00
Ash	129	0.98	128.01	59	1.00	58.00	1,626	1.00	1,625.00
Reference site	13	0.98	12.01	13	1.00	12.00	650	1.00	649.00

Conclusions

- The activity levels of the soil radionuclides as ^{226}Ra, ^{232}Th, ^{40}K, and artificial ^{137}Cs were determined using GRS with Germanium detector in samples of soil collected from nearby of the dumpsite.

- The highest rate of radioactivity occurred in ash, indicating that radioactive elements and derived isotope were as a result of ash entering the landfill in Ulaanbaatar in winter. Radiation isotopes around the waste point are higher than the ambient radiation level.

- But it does not affect human health and the environment. The Ra_{eq} and other hazard indices were less than their respective limiting values showing that the surveyed area has no hazard from health point of view.

Conclusions

- Therefore, the data may provide a general reference level for the area studied and may also serve as an initial research study of Naran Enger landfill and surrounding area in Ulaanbaatar, Mongolia.

- In the future, we planning to continue the accumulative impact assessment of Ulaanbaatar city and to collect soil samples from different residential area and city center for protect human health.

- In the future, important to take lots of samples from different locations and to evaluate to be accumulated impacts on the environment and human health.

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Case Study

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Radioactive Levels and Human Health Effects in a Dumpsite on Ulaanbaatar City, Mongolia

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Abstract: Most of the solid waste from Ulaanbaatar city during the cold season is ash from the partial combustion of coal. Burial of the ashes with other solid wastes has affected radioactive isotope levels in the soil. We investigated levels of radionuclides ^{226}Ra, ^{232}Th, ^{40}K, and ^{137}Cs in soil samples collected from the Naran Enger landfill using a gamma-ray spectrometer. The radioactivity of naturally occurring radionuclides in the soil samples was highest underneath the buried waste zone, and lowest around the ger areas and at the initial reference location. In the buried zone, activity of ^{40}K isotope was two times higher than the world average. The results showed that radium equivalent activity (Ra_{eq}) ranged between 69 and 183 $Bq \cdot kg^{-1}$, and the Ra_{eq} of ash was 338.3 $Bq \cdot kg^{-1}$. The external and internal hazard indexes were 0.2 and 0.5, respectively. From the Ra_{eq}, H_{in}, H_{ex}, D_{out}, and D_{in} values, we calculated lifetime cancer risk and found the risk to be $(0.8-1.58) \times 10^{-3}$. Current values of Ra_{eq} and hazard indices were found to be within the recommended limits. **DOI: 10.1061/(ASCE)HZ.2153-5515.0000721.** *© 2022 American Society of Civil Engineers.*

Author keywords: Naran Enger; Landfill; Radioactive isotopes; Hazard index.

Introduction

Urban pollution has a significant negative impact on the health of the population and the socioeconomy (Wang and You 2021). Ulaanbaatar is located in central Mongolia and is the most important region in the country (Dorjsuren et al. 2021). Ulaanbaatar city has less radioactive material than other large cities in the world. However, depending on the location and nature of the waste, the level of radioactive isotopes in the soil may have increased over the last two decades. In the central landfills, the waste mainly comprises household and domestic items. Nonetheless, the composition of the waste is currently inappropriate as it allows organic and solid wastes, construction waste, and clinical waste to interact and consequently generate hazardous waste.

Soil pollution depends on the solid waste properties and structures. A study by the Japan International Cooperation Agency (JICA) found that during 2005–2006, solid waste from Ulaanbaatar consisted of food waste (23%–36%), cotton waste (1%–4%), paper (13%–22%), plastic (14%–22%), metal (7%), and ashes (49%) (JICA 2007). There is also large seasonal variation in solid waste, specifically between summer and winter. During the winter, the proportion of ash is 60.2%; this is much lower during the summer (JICA 2005). Combustion of coal results in the generation of huge amounts of ash, which is the primary environmental problem. This large concentration of ash represents one potential reason for increased soil radioactivity (Gupta et al. 2013; Mondal et al. 2006).

Soil radioactivity is one of the main factors involved in the pollution of air, soil, and water habitats. Soil type strongly affects the behavior of radionuclides in soil and the soil retention characteristics (El-Taher 2013). It is important to estimate the natural radioactivity levels in soil and rock to evaluate the terrestrial gamma dose rate of outdoor environments (Mehra et al. 2007). The geology around Ulaanbaatar city is dominated by Paleozoic sedimentary rock or sandstone, conglomerate, and mudstone rocks. The occurrence and distribution of radioactive material in the soil and groundwater are controlled primarily by the local geology,

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