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PRELIMINARY PATHWAY ANALYSIS FOR YMP PRECLOSURE BIOSPHERE DOSE ASSESSMENT

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INTRODUCTION

The preliminary preclosure biosphere dose assessment for the Yucca Mountain Project (YMP) involves the calculation of a radiation dose to a subsistence farmer living near the proposed Yucca Mountain repository. Eight radionuclides, H-3, Co-60, Kr-85, Sr-90, Ru-106, I-129, Cs-134, and Cs-137, are considered in this study[1]. Radiation doses resulting from unit release rates of these radionuclides are analyzed. Total dose has been broken down into components that result from various exposure pathways. By using this approach, the most important pathways that deliver a radiation dose to a subsistence farmer can be clearly identified.

MODEL DESCRIPTION

For this study, it is assumed that radionuclide release to the accessible environment is from a stack, and atmospheric dispersion is the only radionuclide transport mechanism. The radionuclides under consideration are released at a unit rate of 1 μCi/sec with 1-hour duration. It is also assumed that the atmospheric dispersion factor at a location of interest is equal to one, that is $\chi/Q = 1$ sec/m^3, where χ is the concentration at the location (Ci/m^3), and Q is the release rate (Ci/sec). Since radiation dose is directly proportional to χ/Q, by using this approach the dose fraction (%) through various exposure pathways can be evaluated without specific information about meteorological conditions.

A computer code, GENII-S [2], was used to calculate the radiation dose. Environmental and agricultural data were taken from the results of a site-specific survey and/or literature survey[3]. As a design feature of GENII-S, four-season doses were calculated to model a short-term radionuclide release. Seasonal dose effects are due to different mechanisms of radionuclide accumulation in crops [4]. All applicable pathways were evaluated in order to calculate dose to humans. These pathways were inhalation, ingestion (leafy vegetables, root vegetables, fruit, grain, beef, poultry, milk, egg, drinking water, and soil ingestion), and external (plume submersion and surface soil exposure).

RESULTS AND DISCUSSION

The radiation dose fractions (%) for each pathway for the eight radionuclides in the four seasons are shown in Table 1. For each radionuclide, the highlighted numbers indicate the identified important pathways.

As can be seen, each pathway contributes a different fraction of radiation dose to humans during different seasons. In autumn, consumption of leafy vegetables, beef, and milk contributes more than 90% of the total dose for some radionuclides. Due to model assumptions that a release occurs immediately prior to harvest, the highest dose occurs in autumn. Thus, it is possible that radionuclides on the leafy vegetables are ingested by humans, and radionuclides on fresh forage are ingested by animals eventually contributing to human dose, without radiological and weathering decays. This assumption results in the worst case scenario for the release, which serves as the most conservative radiation dose estimation. In contrast, inhalation and external exposure become the important pathways during the winter, based on the assumption of no leafy vegetables and fresh forage available for consumption at that time. The ingestion pathway is mainly through plant root uptake of radionuclides from the soil for a winter release. The ingestion dose fraction is lowest in the winter, increases during the spring and summer, and is highest in autumn

DISCLAIMER

CONCLUSIONS

The calculated dose fractions for the radionuclides of interest show that each pathway contributes a different dose to humans during different seasons. In the worst scenario season, three ingestion pathways, leafy vegetables, beef, and milk consumption, are the critical pathways for potential human dose. Inhalation and soil exposure are important pathways during the winter.

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Table 1. Dose Fraction (%) by Exposure Pathway and Radionuclide in Four Seasons

Winter	Co-60	I-129	Ru-106	H-3	Cs-134	Cs-137	Sr-90	Kr-85
Inhalation	**74.99**	**50.11**	**98.73**	**100.00**	**37.74**	**38.44**	**82.19**	0.00
Leafy Veg.	0.07	0.24	0.05	0.00	0.48	0.67	6.23	0.00
Other Veg.	0.03	1.59	0.01	0.00	0.20	0.29	3.14	0.00
Fruit	0.05	2.34	0.02	0.00	1.34	1.91	1.44	0.00
Cereals	0.00	2.42	0.00	0.00	0.10	0.14	1.15	0.00
Meat	0.12	**23.37**	0.20	0.00	**16.63**	**23.55**	2.93	0.00
Poultry	0.02	0.00	0.02	0.00	2.41	3.35	0.02	0.00
Cow Milk	0.01	**16.69**	0.00	0.00	7.62	10.42	2.69	0.00
Eggs	0.00	1.34	0.00	0.00	0.10	0.15	0.05	0.00
Soil Ing.	0.02	1.67	0.01	0.00	0.10	0.13	0.11	0.00
Water	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plume	0.49	0.00	0.02	0.00	0.70	0.38	0.00	**100.00**
Surface Soil	**24.19**	0.22	0.94	0.00	**32.57**	**20.57**	0.05	0.00
Spring								
Inhalation	**54.23**	0.49	**63.73**	**100.00**	4.46	4.34	**24.52**	0.00
Leafy Veg.	**16.43**	**18.59**	8.43	0.00	**15.87**	**16.40**	**37.92**	0.00
Other Veg.	0.02	0.02	0.01	0.00	0.03	0.03	0.94	0.00
Fruit	0.04	0.02	0.01	0.00	0.17	0.22	0.45	0.00
Cereals	0.00	0.02	0.00	0.00	0.01	0.02	0.34	0.00
Meat	10.58	**50.11**	**27.18**	0.00	**53.84**	**54.61**	**19.77**	0.00
Poultry	0.01	0.00	0.02	0.00	0.31	0.38	0.01	0.00
Cow Milk	0.82	**30.72**	0.00	0.00	**21.36**	**21.60**	16.00	0.00
Eggs	0.00	0.01	0.00	0.00	0.01	0.02	0.02	0.00
Soil Ing.	0.01	0.02	0.01	0.00	0.01	0.01	0.03	0.00
Water	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plume	0.35	0.00	0.01	0.00	0.08	0.04	0.00	**100.00**
Surface Soil	**17.49**	0.00	0.60	0.00	3.85	2.32	0.01	0.00

Table 1. Dose Fraction (%) by Exposure Pathway and Radionuclide in Four Seasons (Cont.)

Summer	Co-60	I-129	Ru-106	H-3	Cs-134	Cs-137	Sr-90	Kr-85
Inhalation	**42.42**	0.32	**54.16**	**100.00**	3.14	2.90	14.64	0.00
Leafy Veg.	**12.85**	**12.27**	7.16	0.00	**11.19**	**10.95**	**22.64**	0.00
Other Veg.	4.18	4.32	1.74	0.00	3.39	3.76	7.93	0.00
Fruit	5.96	6.40	2.43	0.00	5.01	5.42	11.09	0.00
Cereals	8.70	9.07	3.75	0.00	7.10	7.98	**16.51**	0.00
Meat	10.56	**41.08**	**29.27**	0.00	**45.87**	**46.76**	**15.24**	0.00
Poultry	0.55	0.00	0.96	0.00	2.50	2.77	0.04	0.00
Cow Milk	0.78	**25.61**	0.00	0.00	**18.90**	**17.75**	11.77	0.00
Eggs	0.03	0.91	0.00	0.00	0.10	0.12	0.11	0.00
Soil Ing.	0.01	0.01	0.00	0.00	0.01	0.01	0.02	0.00
Water	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plume	0.28	0.00	0.01	0.00	0.06	0.03	0.00	**100.00**
Surface Soil	**13.68**	0.00	0.51	0.00	2.71	1.55	0.01	0.00
Autumn								
Inhalation	8.24	0.02	10.53	3.98	0.29	0.24	1.53	0.00
Leafy Veg.	**41.26**	**16.78**	**18.59**	**21.59**	**16.33**	**16.01**	**41.26**	0.00
Other Veg.	3.61	1.44	1.61	9.68	1.38	1.39	3.50	0.00
Fruit	5.07	2.04	2.19	**20.10**	1.97	1.93	4.94	0.00
Cereals	7.81	3.08	3.38	13.65	3.00	2.96	7.62	0.00
Meat	**28.67**	**47.96**	**62.71**	7.20	**54.03**	**54.79**	**22.53**	0.00
Poultry	0.48	0.00	0.88	1.08	0.96	0.92	0.02	0.00
Cow Milk	2.13	**28.38**	0.01	**21.54**	**21.74**	**21.60**	**18.55**	0.00
Eggs	0.03	0.30	0.00	1.18	0.04	0.04	0.05	0.00
Soil Ing.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Water	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Plume	0.05	0.00	0.00	0.00	0.01	0.00	0.00	**100.00**
Surface Soil	2.66	0.00	0.10	0.00	0.25	0.13	0.00	0.00

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