Preliminary Evaluation of the Suitability for Geological Disposal of a Solidified Decommissioning Waste

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1. Introduction

The generation of large amounts of radioactive wastes is now of important issue in the decommissioning of nuclear power plants (NPPs). Various types of radioactive wastes are generated from decommissioning of NPPs (Table I).

Table I. Typical Radioactive Wastes from the Decommissioning of a PWR [1]

Radioactive wastes	Amount (ton)	%
Activated steel	650	10.5
Activated concrete	300	4.9
Contaminated ferritic steel	2,400	38.7
Steel likely to be contaminated	1,100	17.1
Contaminated concrete	600	9.7
Contaminated lagging	150	2.4
Contaminated technological wastes	1,000	16.1
Total	6,200	100

Solidification technologies need to be developed to improve the acceptability for safe disposal of the wastes generated during treatment processes for the volume reduction of decommissioning wastes. In addition, it is necessary to assure disposal safety through safety and suitability assessments for a suggested disposal method according to the classification of radioactive wastes [2].

In this study, a preliminary suitability for a solidified concrete waste from decommissioning of NPPs using MKPC (Magnesium Potassium Phosphate Cement) was evaluated for both landfill and near-surface disposal sites based on safety assessment and acceptance criteria.

2. Solidified Decommissioning Wastes

Table II. Composition of the Solidified Waste

Component	Wt. %
SCPW[1)]	50
MgO	10.07
KH_2PO_4	22.66
H_2O	14.68
H_3BO_3	0.5
$CsNO_3$[2)]	0.58
$Co(NO_3)_2$[2)]	0.87
$Sr(NO_3)_2$[2)]	0.63
Total	100

[1)] simulated concrete powder waste
[2)] nuclides contained in the wastes

A recent research suggested the use of magnesium potassium phosphate cement (MKPC) to solidify concrete powder waste generated from decommissioning of nuclear power plants [3]. It has been also demonstrated that the concrete powder waste solidified with MKPC can be used to immobilize radioactive concrete waste [3]. The composition of the simulated waste solidified by the MKPC is given in Table II.

3. Safety Assessment

Safety assessments for the solidified wastes using MKPC were carried out for landfill disposal and near surface disposal. In the case of landfill disposal, the RESRAD-Onsite code developed by ANL (Argonne National Laboratory, USA) was used for the safety assessment [4]. On the other hand, the GS-TRENCH code developed by KAERI was used for the safety assessment of near surface disposal [5]. Cesium (Cs) and cobalt (Co) were presumed to be major radionuclides contained in the waste.

Table III. Major Input Data for the Safety Assessment of Landfill Disposal

Parameter	Unit	Value
Area of contaminated zone	m^2	14,250
Thickness of contaminated zone	m	16
Length parallel to aquifer flow	m	600
Depth of cover	m	0.5
Density of cover	g/cm^3	1.6
Erosion of contaminated zone	m/yr	0.001
Total porosity of contaminated zone	-	0.15
Effective porosity of saturated and unsaturated zones	-	0.2
Hydraulic conductivity of contaminated zone and unsaturated zone	m/yr	10
Hydraulic conductivity of saturated zone	m/yr	100
Thickness of unsaturated zone	m	4
Hydraulic gradient of saturated zone	-	0.02
Evaporation coefficient	-	0.68
Water table drop rate	m/yr	0.001
Well pumping rate	m^3/yr	250
Wind speed	m/sec	2.1
Precipitation	m/yr	1.7
Runoff coefficient	-	0.2
Watershed are for nearby stream or pond	m^2	1,000,000
Humidity in air	g/cm^3	8.0
Inhalation rate	m^3/yr	8,400
Exposure duration	yr	30
Indoor time fraction	-	0.5
Outdoor time fraction	-	0.25

3.1. Landfill disposal

Table III shows major parameters and their values used in the safety assessment for landfill disposal using RESRAD-Onsite. Fig. 1 shows the calculated exposure dose with time for the landfill disposal. Fig. 2 also shows exposure dose ratio of each pathway for the Co-60 and Cs-137.

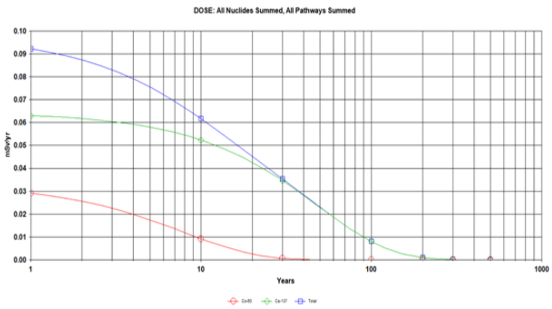

Fig. 1. Exposure dose with time in the landfill disposal.

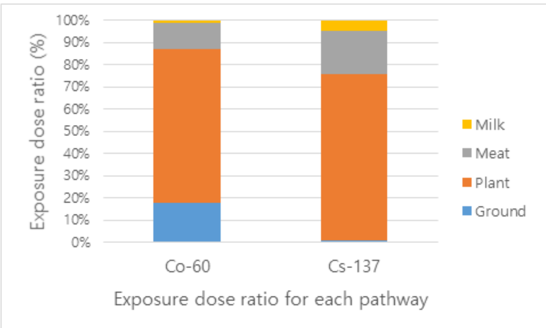

Fig. 2. Exposure dose ratio of Co-60 and Cs-137 for each pathway.

3.2. Near-surface disposal

Fig. 3 shows schematic illustration of the GS-TRENCH model used in the safety assessment for near-surface disposal.

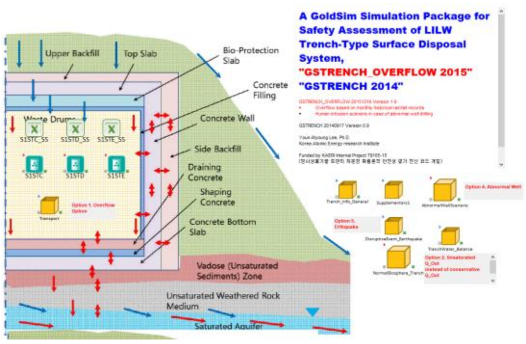

Fig. 3. Safety assessment model of the GS-TRENCH code for the near-surface disposal.

Fig. 4 shows the calculated exposure dose for farmers with time in the near-surface disposal. Fig. 5 also shows exposure dose ratio of exposure groups for the Co-60 and Cs-137.

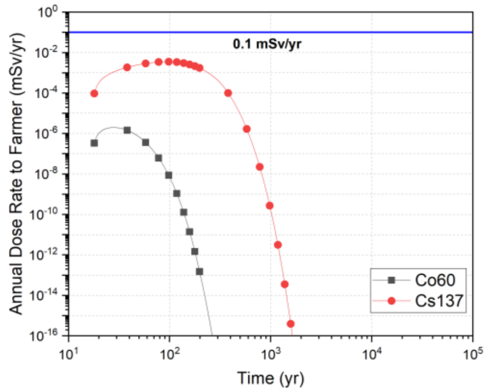

Fig. 4. Exposure dose for farmers with time in the near-surface disposal.

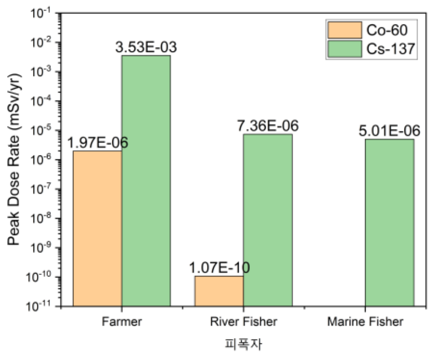

Fig. 5. Peak dose ratios of Co-60 and Cs-137 for exposure groups in the near-surface disposal.

4. Preliminary Suitability Evaluation

Based on the results of safety assessment for the landfill and near-surface disposal sites, the solidified decommissioning concrete waste using MKPC is postulated to be acceptable to both disposal sites in the of radiological aspect because their calculated exposure doses are estimated to be less than the regulatory safety goal (0.1 mSv/yr).

The characteristics of the solidified waste form using MKPC was also estimated to be acceptable to the both radioactive waste repositories due to following facts [3]:

1) the compressive strength of the solid waste using MKPC showed > 45 MPa, which satisfies the waste acceptance criterion (3.45 MPa), and
2) the leaching indices of Cs, Co, and Sr analyzed following the ANS 16.1 procedure, were 11.45, 17.63, and 15.66, respectively; these also satisfy the waste acceptance criterion (> 6).

Therefore, based on the results of safety assessments and characteristic study for the solid waste form, it can be preliminarily concluded that MKPC can be used to immobilize radioactive concrete wastes generated during the decommissioning of nuclear power plants and suitable to both landfill and near surface disposal.

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