Effect of highly concentrated cations on hydraulic barrier performance of zeolite-amended clay liner

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Key Words: Zeolite, Clay liner, Cesium, Exchangeable cation, Hydraulic conductivity

1. BACKGROUND AND OBJECTIVES

The Fukushima Daiichi nuclear disaster in 2011 generated large quantities of waste with radioactive pollution such as Cs. When the radioactive waste is managed in existing MSW landfill sites which allow permeation of rainfall, leachate through waste body containing radioactive substances must be isolated from the surrounding ground. Although geosynthetic clay liners (GCLs) amended with zeolite are expected to act as a bottom liner in disposal facilities because zeolite has a very high sorption capacity for Cs, a limited number of research has focused on hydraulic conductivity of zeolite-amended GCLs. Since it is required to understand the effects of cations on hydraulic conductivity of zeolite-amended GCL for proper design of a liner system, a series of laboratory tests including column test using a flexible-wall permeameter were conducted with various permeants containing cations.

2. TEST METHODS

The cation exchange capacity and the sorption characteristics of Na-bentonite and powder zeolite were studies. Five types of GCLs composed of those materials were tested with five types of permeants, as shown in Table 1 and 2. Hydraulic conductivity and cation concentration of effluent were measured.

Table 1 Overview of each GCLs used.

GCL name	Structure	Zeolite (g/m^2)	Bentonite (g/m^2)
Type-A	-	0	3,000
Type-B1	Mixed	3,000	3,000
Type-B2	Mixed	1,000	3,000
Type-C1	Separated	3,000	3,000
Type-C2	Separated	1,000	3,000

Table 2 Chemical composition of permeants used for column test.

	Na (mol /L)	K (mol /L)	Ca (mol/L)	Cs (mg/L)
Distilled water	-	-	-	
NaCl solution	0.4	-	-	1.0
KCl solution	-	0.4		1.0
$CaCl_2$ solution	-	-	0.1	1.0
Multi-ion solution	0.4	0.4	0.1	1.0

3. MAIN ACHIEVEMENTS

(1) Results of column permeation tests showed that hydraulic conductivity of Type-B1 (mixed) was lower than that of A (only bentonite) except for the case of KCl solution. Cations in influent was absorbed to zeolite and the cation concentration decreased resulting in reduction of the adverse effects on hydraulic conductivity of GCL.

(2) When KCl solution was permeated, Type-B1 (mixed) and C1 (separated) showed hydraulic conductivity equivalent to or higher than Type-A (only bentonite). It is presumed that ion exchange between K^+ in influent and Ca^{2+} in zeolite occurred. Increase in the Ca^{2+} concentration of solution contacting with bentonite layer significantly lower performance of GCLs.

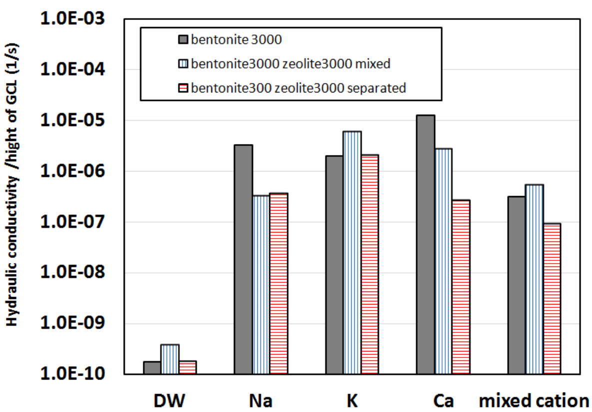

Figure 1 Hydraulic conductivity with various solutions

(3) Regardless of the type of permenat, Type-C1 (separated) showed a hydraulic conductivity lower than Type-B1 (mixed). This is probably because the amount of bentonite in unit volume, as well as cations released from zeolite were key factors on hydraulic barrier performance of zeolite-amended GCLs.