Parameters and Procedures of Electro-kinetic Decontamination Experiments for Radioactive Concrete

Chanyoung Kim, Sungyeol Choi, and Myoungsu Shin*

Ulsan National Institute of Science and Technology, 50 UNIST-gil, Ulju-gun, Ulsan, Republic of Korea

*msshin@unist.ac.kr

1. Introduction

The electro-kinetic method is a technology to transport ions and colloids by applying an electric field to a porous medium such as soil and concrete. This technology can allow to extract metallic nuclides deep inside of concrete without mechanical destruction of the structure. To maximize its advantages, the factors that affect the efficiency of decontamination should be properly taken into account. This study aims at developing optimized decontamination procedures through the investigation of test data from previous studies.

2. Normalization for Comparison of Decontamination Efficiency

2.1 Variable Selection for Normalization of Efficiency

Previous studies about the decontamination of radioactive concrete focused on variables such as variety of solution and zeta-potential at double-layer as the key factors that affect to efficiency [1]. Several researchers [2] pointed out the effects of pH on the extraction of cobalt from concrete, but quantitative analysis about the decontamination efficiency by pH values were not have been performed. Also, none of them discussed the effects of the contamination procedure in detail. In this paper, the separation factor that affects to decontamination are investigated for each pH values. Finally, the sample contamination procedures of each study were evaluated.

2.2 Separation Factor Description

The results of concrete leaching tests for different pH values conducted by Achternbosch et al. [3] were used to estimate the effect of pH on the mobilization of cobalt in concrete. The investigation conducted by Achternbosch et al. [3] are given in Table 1. Also, the test data from Faiz et al., 2016 [4] are used to estimate the mobilization of cesium. The pH effect factors are described in Table 2. Referring to Achternbosh et al. [3], metallic elements existing in concrete may have three bonding forms: sorption, incorporation, and encapsulation. The contamination procedure of each studies could affect to bonding forms of nuclides, which finally affect to proportion of contaminants released from concrete.

Table 1. Leaching Test Results by pH of Solution [3]

Element	Cement (unit: ppm)	
	DEV-S4 (water)	Availability (pH 4)
Ba	1.7	135
Co	< 0.1	1

Table 2. Separation Factor of Nuclides with different pH values of Solution

Author	pH	Nuclides	Separation factor
[2]-Series A1)	7	Cs Co	1 1
[2]-Series A2)	7	Cs Co	1 1
[2]-Series B3)	7	Cs Cs (non-voltage)	1
[1]-0.1 M acetic acid4)	2.87	Cs Co	1.15 5
[1]-0.01 M Acetic acid4)	3.37	Cs Co	1.15 5

1) samples contaminated during casting, non-carbonated
2) samples contaminated during casting, carbonated
3) samples contaminated after curing
4) samples contaminated after curing with solution has high concentration, In case of 0.01 M acetic acid, it is washed chemically before performing electro-kinetic experiment

Finally, numbers of moles of extracted contaminants were normalized by the separation factor and the volume of the specimen.

$$C_{i\_eff} = \frac{m_i}{V_{sam} D_{pH}} \qquad (1)$$

Here, C_{i_eff} is the effective concentration of nuclides i, m_i is the numbers of moles of nuclides i in the concrete sample, V_{sam} is the volume of the concrete sample, and D_{pH} is the separation factor of nuclides i by the pH value of the solution. Equation 1 is used to normalize the efficiency of decontamination in this study. After the normalization, it was discussed by compared the value of each setup.

3. Results of Normalization & Discussion

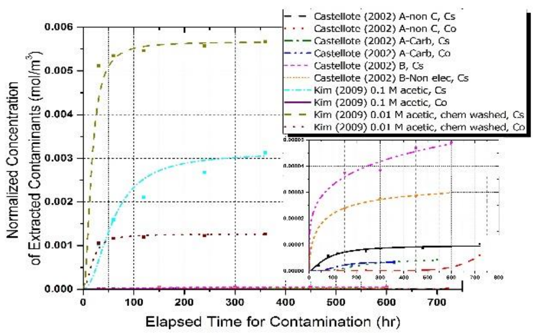

Fig. 3. Time vs Concentration of Extracted Contaminants.

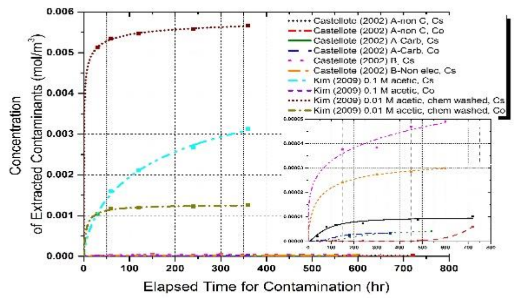

Fig. 4. Time vs Proportion of Extracted Contaminants.

Fig. 1. and Fig. 2. describe the normalized molar concentration and original molar concentration of the extracted contaminants with time-domain. For more correct evaluation, bonding forms of contaminants at each setup were discussed. In case of Series B of Castellote et al. [2], 60% of contaminants were extracted when the electric field was not applied to cell. As previously noted, it was contaminated after curing, so that the bond strength of contaminants with cement matrix would be weak. Kim et al. [1] also contaminated the samples after curing, but extraction of nuclides was not observed when proper solution and electric field were not applied. Considering this, contaminants in samples of Kim et al. [1] has stronger bonding form, and it is proper to compare with the results of samples contaminated during casting. From the result of series A of Castellote et al. [2], increase of extraction of cobalt and decrease of extraction of cesium were observed when samples were carbonated. In contrast, Kim et al. [1]'s setup using 0.01 M acetic acid with chemical washing shows high efficiency both for cesium and cobalt.

4. Conclusions

In this paper, result of normalization by separation factor for each pH value and effects of contamination method were studied.

- Trend of normalized data were similar with original data because of the trend of separation factor by each pH values.
- Using 0.01 M acetic acid with chemical washing shows highest efficiency from normalized concentration of extracted contaminants.
- Because the samples contaminated after curing shows weak bonding strength, it should be considered for correct comparison.

REFERENCES

[1] Kim, G.N.; Yang, B.I.; Choi, W.K.; Lee, K.W.; Hyeon, J.H. (2009) Washing-electrokinetic decontamination for concrete contaminated with Cobalt and Cesium, Nuclear Engineering and Technology, 41; 1079-1086.

[2] Castellote, M.; Andrade, C.; Alonso, C. (2002) Nondestructive Decontamination of Mortar and Concrete by Electro-Kinetic Methods Application to the Extraction of Radioactive Heavy Metals, Environmental science & Technology, 36; 2256-2261.

[3] Achternbosch, M.; Bräutigam, K.; Hartlieb, N.; Kupsch, C.; Richers, U.; Stemmermann, P.; Gleis, M.; (2003) Heavy metals in cement and concrete resulting from the co-incineration of wastes in cement kilns with regard to the legitimacy of waste utilisation, Forschung-szentrum Karlsruhe GmbH.

[4] Faiz, Z.; Fakhi, S.; Bouih, A.; Outayad, R.; Benkdad, A.; Hannache, H. (2016) Leaching study of cesium from spent ion-exchange resins and Portland cement package, International Journal of Environmental Science and Technology, 1-8.