

INFLUENCE OF SPECIFIC SURFACE RATE OF CEMENT SOLIDIFIED FLY ASH ON LEACHED AMOUNT OF SOLUBLE SUBSTANCES

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ABSTRACT

Tank leaching tests with different size of cubic solidified air pollution control residue (APCR) and cylindrical solidified APCR were conducted to evaluate the effect of size of solidified APCR on leaching rate and the applicability of leaching mode. It was found that increasing the specimen size could decrease the leaching rate per weight of solidified APCR. It is suggested that the surface dissolution model might need to be improved.

INTRODUCTION

In Japan, the incineration rate of municipal solid waste (MSW) was reached to 80% in 2018¹⁾ and air pollution control residue (APCR) from MSW incineration contains highly soluble salts, causing high concentration of salts in leachate. The high concentration of soluble salts in leachate affects water quality and water use in receiving water body. Therefore, it is required to reduce the concentration of salts in leachate.

On the other hand, the stabilization of APCR is required because of hazardous heavy metals in APCR. Although solidification with cement is used for stabilizing APCR cannot insolubilize the salts, it can decrease the mobile speed of salts through the solidified APCR by its dense structure. Two mechanisms of salt leaching from solidified APCR have been reported: diffusion dissolution at the surface of solidified APCR. Both phenomena are affected by the surface area of solidified APCR. Therefore, it is expected that increase in volume of solidified APCR can decrease the leaching rate per weight of solidified APCR.

The objectives of this study were to evaluate the effect of volume of solidified APC residue on the leaching rate of salts per weight of solidified APC residue by tank leaching tests. And the applicability of the one-dimensional model to solidified APC residue was considered using cylindrical solidified APC residue.

EXPERIMENTAL

APC residue and solidified specimen

APC residue was sampled from an MSW incineration plant in Miyazaki city, Japan. This facility configured mechanical grate furnace, with flue gas treatment using

activated carbon and $\text{Ca}(\text{OH})_2$.

The solidified specimen was prepared with the APC residue(A), Portland cement(C) and water(W) according to the following ratio in duplicate: C/A, 20% and W/(A+C), 40%. The mixture was homogenized, poured into a cubic mold with 4, 6, or 8 cm each side or a cylindrical mold with 5 cm ϕ x10 cm long, and then rapped with a thin plastic film. After 7 days curing, one of the duplicates was used for tank leaching test, and the other was dried, ground, and then used for serial batch test. For a tank leaching test, the bottom and side of cylindrical solidified specimen were sealed with a water-proofing agent.

Tank leaching test

A tank leaching test was performed with distilled water: for cubic solidified specimen, 0.6 L for 4 cm specimen, 1.2 L for 6 cm specimen, and 2.3 L for 8 cm specimen; and for cylindrical solidified specimen, 1.5 L. The solution was renewed after 0.125, 0.25, 0.5, 1, 2, 4, 8, and 16 days. An aliquot of leachate was filtered with 0.45 μm membrane filters.

Serial batch test (SBT)

Serial batch test was performed with 10 g of samples and 400 mL of distilled water in a centrifugal tube. After shaking at 200 rpm for 6 hrs, it was centrifuged at 5,000 G, and then supernatant was recovered and filtered. Distilled water of 300 mL was added the centrifugal tube having the residuals, and the same leaching and separation was repeated for three times.

Analytical method

Concentrations of Na and K in solution were determined by atomic adsorption, concentration of Cl by colorimetry with mercury thiocyanate, and porosity of solidified PC residue by mercury porosimetry.

RESULTS AND DISCUSSION

Characteristics of S/S samples

Table 1 shows the leaching amounts of salt by SBT. For each element, the leaching amounts were almost the same between the specimens.

Effect of specimen size

The leaching rate per specimen weight, LR (g/(kg·day)) calculated by Equation 1, for cubic specimen, defined by Equation 1 are shown in Figure 1.

$$LR = \frac{M_i - M_{i-1}}{t_i - t_{i-1}} \quad \cdot \cdot (1)$$

where M_i is the cumulative leaching amount of salt at the i th sampling, and t_i is the elapsed time at the i th sampling. For each element, the LR decreased with increase in the specimen size. The effect of specimen size was clear especially at 0.124 day, and negligible after 4 days. It indicates that increasing the specimen size could decrease the concentration of salts in leachate. In addition, the highest LR appeared at the beginning of leaching test, which indicates that in actual landfill site, it is expected that the concentration of salts in leachate would become the highest at the beginning of landfilling the solidified APCR.

Applicability of the one-dimensional model

The following leaching model²⁾ was considered:

$$M = Q_0(1 - e^{-kt}) + 2SC_0\sqrt{\frac{D_e t}{\pi}} \quad \cdot \cdot (2)$$

where M was the cumulative leaching amount of salt (g/kg), Q_0 is the initial amount of salt content in solidified APCR (g/kg), k is a surface dissolution rate constant (1/s), S is the specific surface area of solidified APCR (m²/kg), C_0 is the initial concentration of salt in solidified APCR (g/m³), D_e is the effective diffusion coefficient of salt (m²/s), and t is elapsed time (s). In this

study, the leaching amounts of salt by SBT were used as the values of Q_0 . The model parameters D_e and k , were determined by tank leaching tests using cylindrical solidified APCR to minimize the residual sum of squares between observed and calculated M . Obtained parameters are summarized in Table 2. The correlation coefficients (R^2) of Na, K, and Cl indicated that the experimental data could fit well into the model. Figure 2 shows the calculated and observed values of the fraction of the cumulative leaching amount calculated by $M_i - M_{i-1}$. At the beginning of leaching test, the calculated fraction was lower than the observed one for each element. It suggests that the surface dissolution model might need to be improved.

CONCLUSIONS

The tank leaching tests with different size of cubic solidified APCR showed increasing the specimen size could decrease the concentration of salts in leachate. The tank leaching tests with cylindrical solidified APCR suggested that the surface dissolution model used might need to be improved.

REFERENCES

- 1)Ministry of the Environment: Municipal solid waste emissions and disposal in FY2018
- 2)K. Suzuki, Y. Ono : Leaching characteristics of stabilized/solidified fly ash generated from ash-melting plant, Chemosphere, Vol.71, pp.922-932, 2008

Table 1 Leaching amounts of salt by SBT (g/kg)

| Specimen | Na | K | Cl |
|-----------|------|------|------|
| Cubic-4cm | 18.4 | 20.6 | 98.1 |
| Cubic-6cm | 19.1 | 21.4 | 106 |
| Cubic-8cm | 20.0 | 21.5 | 103 |
| Cylinder | 20.2 | 23.1 | 118 |

Table 2 Obtained parameters

| | Na | K | Cl |
|---------------------------|-----------------------|-----------------------|-----------------------|
| k (1/s) | 2.0×10^{-9} | 2.8×10^{-9} | 4.8×10^{-9} |
| D_e (m ² /s) | 1.9×10^{-10} | 2.7×10^{-10} | 1.4×10^{-10} |
| R^2 (-) | 0.9989 | 0.9993 | 0.9994 |

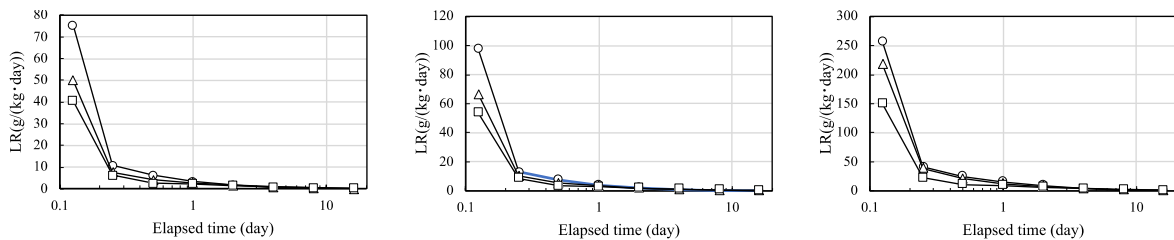


Figure 1 Leaching rate per specimen weight from solidified PAC residue: ○, 4 cm; △, 6 cm; and □, 8 cm

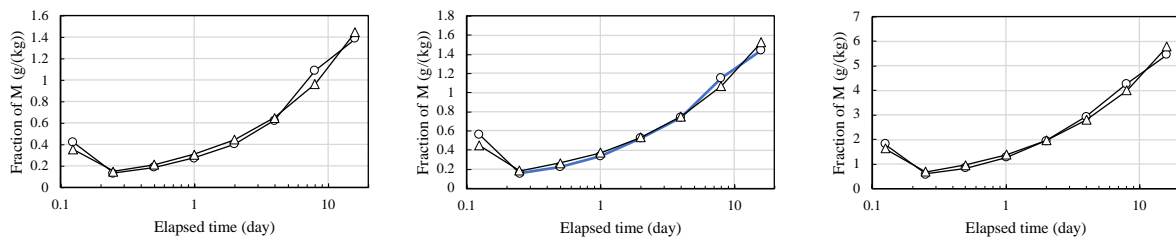


Figure 2 Fraction of the cumulative leaching amount per specimen weight: ○, observed; and △, calculated