

Numerical investigation of the effect of geosynthetic clay liner chemical incompatibility on flow and contaminant transport through a defective composite liner

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Chemical Compatibility of GCL

- GCL is susceptible to chemical attack due to the incompatibility of the bentonite with aggressive leachates containing high cation valency, high ionic strength, or extreme pH

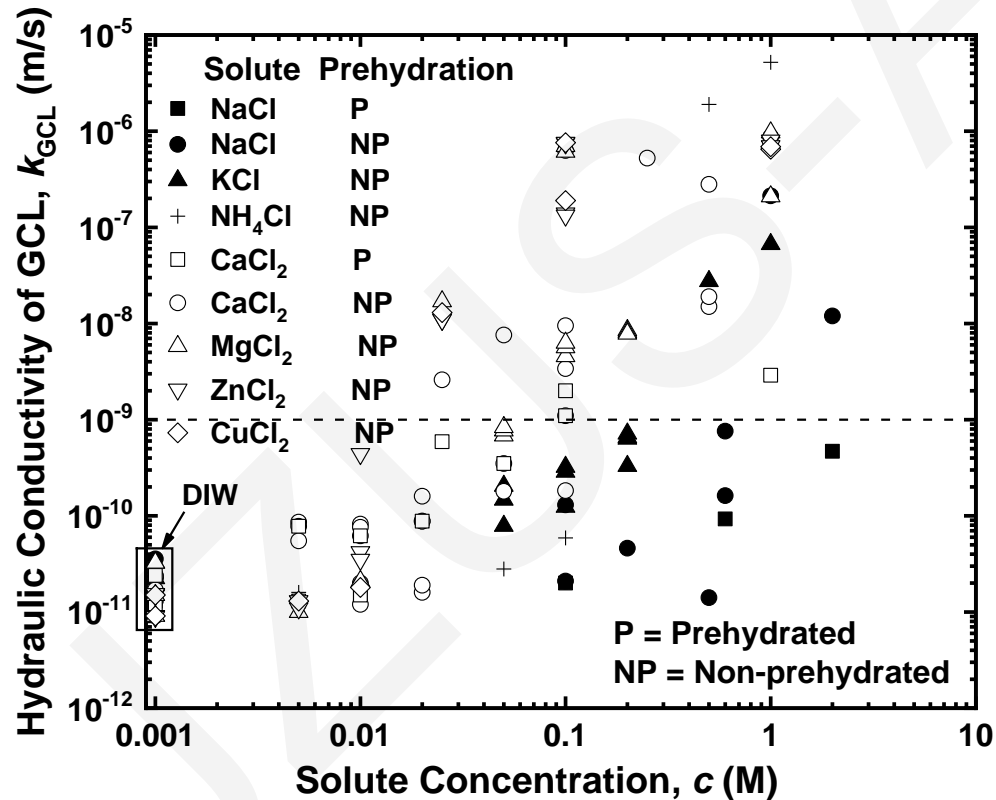
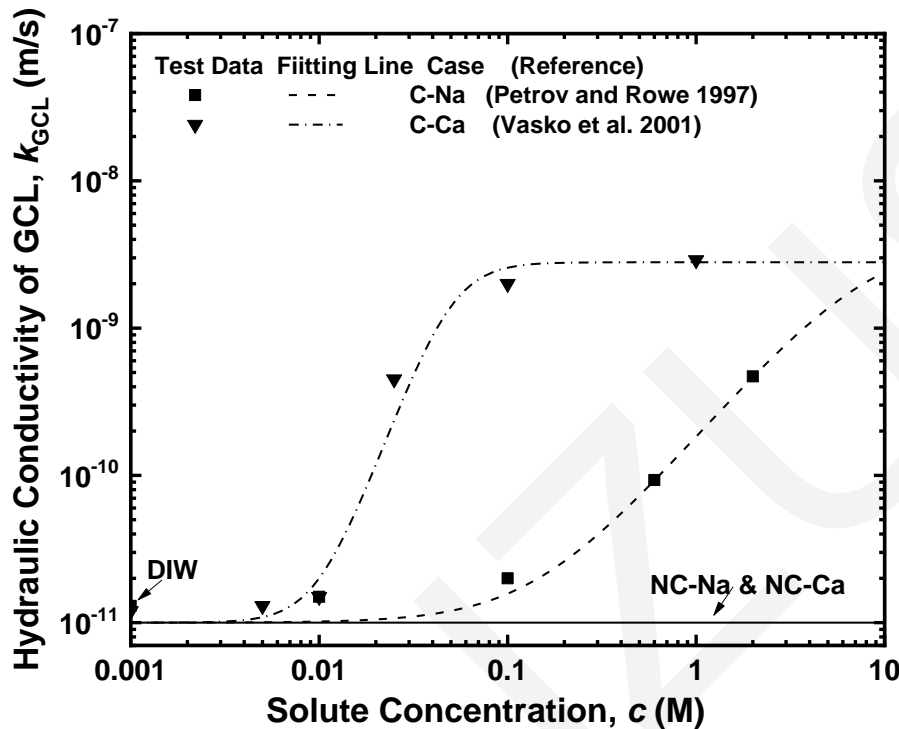


Fig. 1 Hydraulic conductivity of GCL with deionized water and inorganic solutions

The Fitting of k - c Relationship

- The relationship between the hydraulic conductivity of GCL and the concentration of the inorganic solution was well fitted using a Logistic Model



$$k_{GCL} = k_{GCL}^{\infty} + \frac{k_{GCL}^0 - k_{GCL}^{\infty}}{1 + (c/m)^a}$$

k_{GCL}^{∞} = maximum value of k_{GCL} corresponding to the highest permeant concentration

k_{GCL}^0 = initial k_{GCL} in all cases (hydraulic conductivity of GCL permeated with DIW)

c = solute concentration

m = value of c corresponding to

$$k_{GCL} = (k_{GCL}^{\infty} + k_{GCL}^0) / 2$$

a = parameter related to the range of c in which the k_{GCL} varies dramatically

Fig. 3 Hydraulic conductivity of prehydrated GCLs with NaCl or CaCl₂ solutions

Performances of Composite Liner

- Chemical incompatibility of GCL may induce considerable increases of leakage rate and contaminant flux when the GCL is exposed to aggressive leachates from landfills with high concentration levels

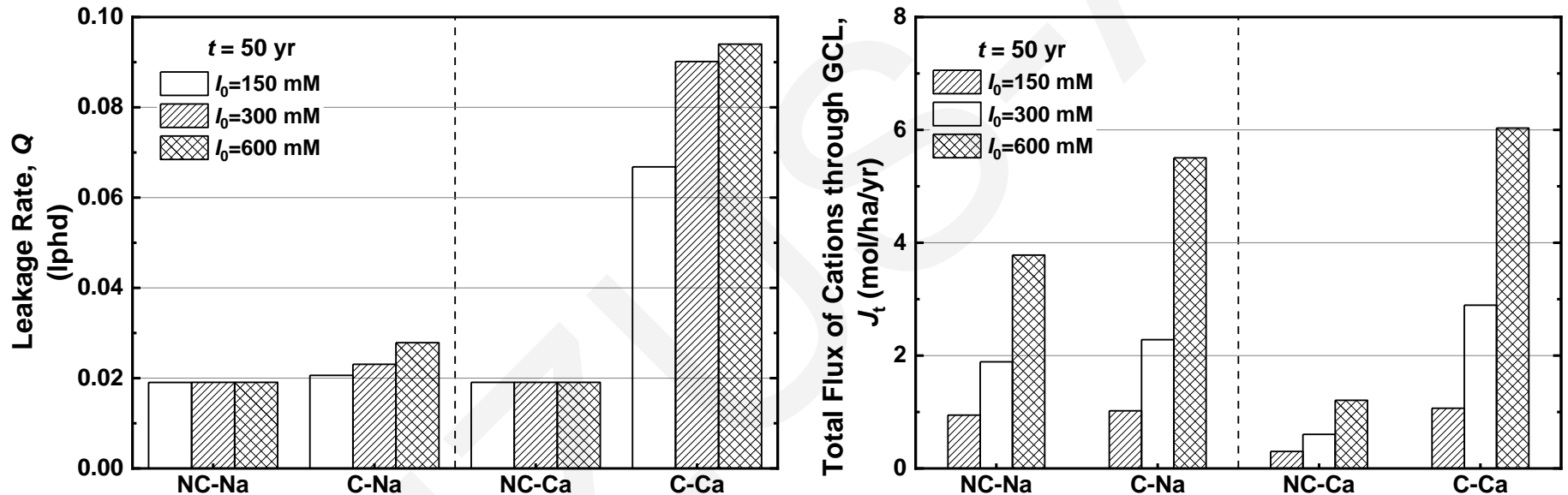
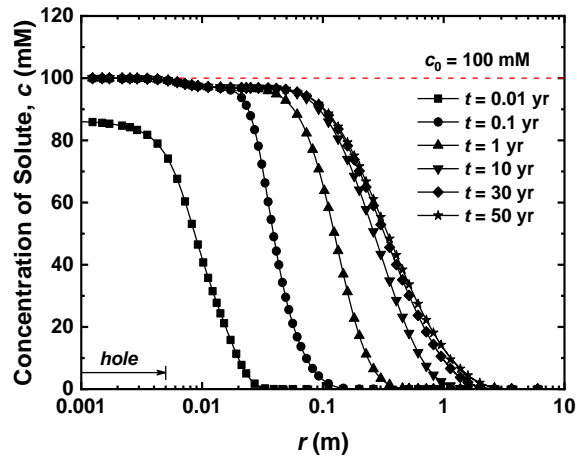
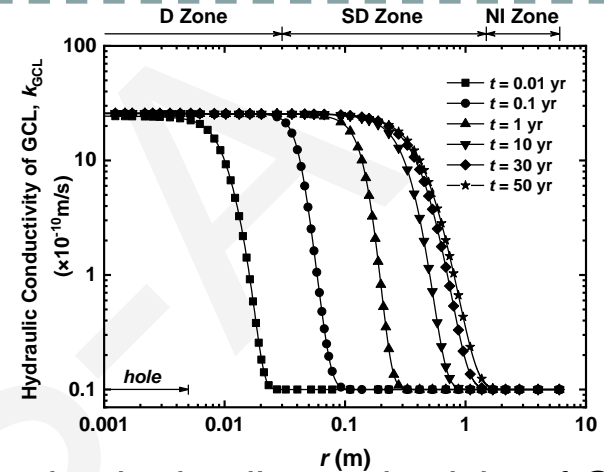


Fig. 5 Leakage rate and total flux of cation through the GCL at $t = 50$ yr for all 4 cases

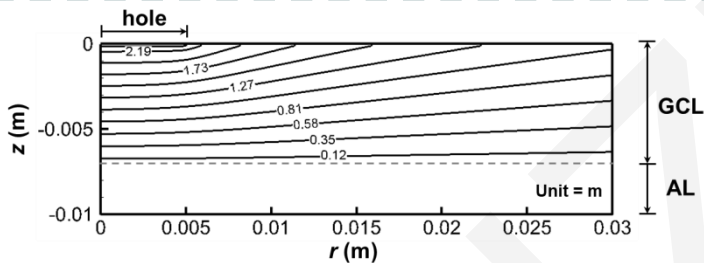
Impact Mechanism



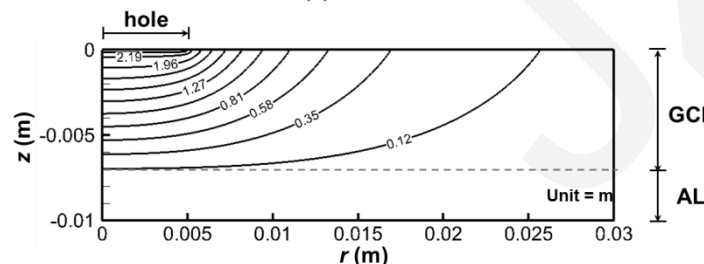
Increasing concentration in GCL



Increasing hydraulic conductivity of GCL

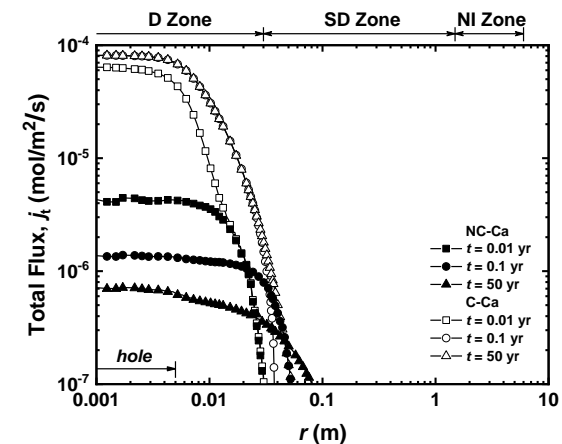
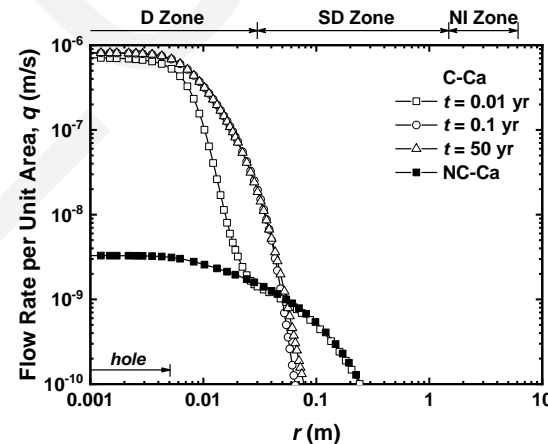


(a) NC-Ca



(b) C-Ca, $t = 50$ yr

Concentrated head distribution



Higher flow rate and contaminant flux in Deterioration Zone

Conclusions

- It is necessary to consider the chemical incompatibility of GCL when evaluating barrier performance of composite liners with defective GMB, especially for a landfill with leachates containing high concentrations of inorganic cations
- The increase of k_{GCL} due to chemical incompatibility results in much higher flow rate and flux in the GCL portion directly beneath the hole, and it also results in a smaller radius of the wetted area
- The chemical incompatibility of GCL significantly increases the ratio of advective flux to diffusive flux through the defective composite liner