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Effect of Sodium Oxide Disulfonate Surfactant on Hydraulic Conductivity in a Soil

계면활성제가 수리전도도에 미치는 영향

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요 약 문

계면활성제를 이용하여 토양에 존재하는 유기 오염물질을 제거하는데 있어서, 계면활성제가 토양과의 상호작용시 투수계수를 상당히 (10^2 이상) 감소시키면 이 복원 방법은 실용성이 없다. 그러므로 본 연구의 목적은 선택된 계면활성제와 투수계수 사이의 상관 관계를 고찰하는데 있다.

본 연구 결과 계면활성제(DOSL) 사용 후 증류수와의 상대적 비교치로써 투수계수는 21~35 % 감소하였다. 이 감소 수치의 의미는 선택된 계면활성제(DOSL)는 토양 복원 연구에 사용될 수 있음을 보여준다.

Key words : 계면활성제, 오염물질, 투수계수, 토양복원

I. Introduction

Extensive research on soil and aquifer remediation has demonstrated that surfactant flushing is a viable alternative for improving the efficiency of pump-and-treat remediation. Even though surfactant solutions may aid in the in-situ washing of hydrophobic organic compounds from soils and aquifers, remediation may be impractical if soil-surfactant interactions result in significant hydraulic conductivity reductions (Allred and Brown, 1994). Surfactant solutions introduced into saturated porous media can alter hydraulic conductivity values by changing fluid density and viscosity, by clogging pores, and by altering the adsorptive properties of soils. Because soil hydraulic conductivity is one of the key factors determining the potential effectiveness of surfactant-based remediation (Edwards et al., 1994), effects of surfactants on saturated hydraulic conductivity must be understood. The objective of this study was to investigate the effects on saturated hydraulic conductivity of the interactions between soil (clay loam), an electrolyte (NaCl), and surfactant, sodium diphenyl oxide disulfonate (DOSL, trade name Dowfax 8390).

II. Materials and Methods

DOSL was obtained from Dow Chemical Co. (Midland, MI) and was used without further purification (Lee, 1999; Lee et al., in press). One Iowa field soil, Webster clay loam, was used for this study. Prior to use the soils were air-dried and passed through a 2 mm sieve (Gonzalez and Ukrainczyk, 1996). They were also oven-dried for 24 hours at 100 °C to decrease the potential for microbial activity during the experiments. Constant-head hydraulic conductivity column tests were conducted using standard methods in the Soil Physics Laboratory of Iowa State University. The columns were 6.4 cm in outer diameter, through a 0.3 cm thick wax liner used to minimize column wall flow reduced the inner diameter to 5.8 cm. The 17 cm high columns were filled with soil to a height of 14.7 cm. A porous ceramic plate beneath the soil prevented loss of soil during leaching. A difference in elevation head of 16.1 cm, equal to a vertical hydraulic gradient of 1.1, was imposed for each test. Duplicate columns were run in the downflow direction for each treatment, and the hydraulic conductivity values were averaged. After columns were packed with soil, deionized water was pumped through the columns for six hours to saturate the soil. Then, using deionized water to impose the constant-head conditions described above, hydraulic conductivity was monitored until the values stabilized at 1.07×10^{-3}cm/s for the Webster clay loam. Leaching solutions were substituted for the deionized water, and changes in saturated hydraulic conductivity were monitored as a function of leaching solution volume. Webster soils was leached with three pore volumes of 4 %(v/v) DOSL (0.064 mol/L) in which the aqueous carrier consisted of either deionized water or a 10 %(w/v) solutions of NaCl (1.7 mol/L). These three treatments were compared with control columns leached with three pore volumes of either deionized water or a 10 %(w/v) solution of NaCl. For graphical comparison the mean hydraulic conductivity values obtained after leaching with three pore volumes were expressed as fractions of the initial values (listed above). Reductions in hydraulic conductivity were calculated percent decreases from the initial values.

III. Results and Disscussions

Choice of suitable surfactants for in situ soil or aquifer remediation depends in part upon maintaining adequate saturated hydraulic conductivity during the washing process. Surfactants that remove contaminants but cause pore clogging in the process are not effective treatment options.

Figure 1 shows the results of the saturated hydraulic conductivity changes in Webster clay loam column. The average hydraulic conductivity of the Webster soil decreased 13 % relative to the initial value of 1.07 x 10^{-3} cm/s, when leached with the 10 % NaCl solution. Hydraulic conductivity reductions were 21 % for DOSL without NaCl and 35 % for DOSL with NaCl, as compared with the initial value. The difference in hydraulic conductivities between DOSL with and without NaCl is similar to the difference in hydraulic conductivities between deionized water and NaCl without DOSL, suggesting that no interaction occurred between the DOSL and the NaCl (Lee et al., in press). Also, these data indicate that the surfactant DOSL does not substantially impact saturated hydraulic conductivity, even in clay-rich soils. Even when decreased by 35 % in the treatment with 4 %(v/v) DOSL and 10 %(w/v) NaCl, the hydraulic conductivity of the Webster clay loam was still above the 1 x 10^{-4} cm/s cited by Rajput et al. (1994) as required for successful remediation. Attempts at surfactant-assisted remediation in clay-rich soils must consider the possibility of hydraulic conductivity losses due to the interactions between soil and surfactant and/or electrolytes. This problem may be especially prominent in saline soils as shown by our results with NaCl-surfactant solutions.

IV. Conclusions

Surfactant type was especially important in affecting conductivity (Lee et al., in press). The double-head hexadecyl disulfonate surfactant, sodium diphenyl oxide disulfonate (DOSL, trade name Dowfax 8390), caused much less pore clogging during surfactant leaching than the single-head sulfate surfactant (Lee, 1999). On the basis of our experiments DOSL appears to be a good candidate for surfactant-aided remediation.

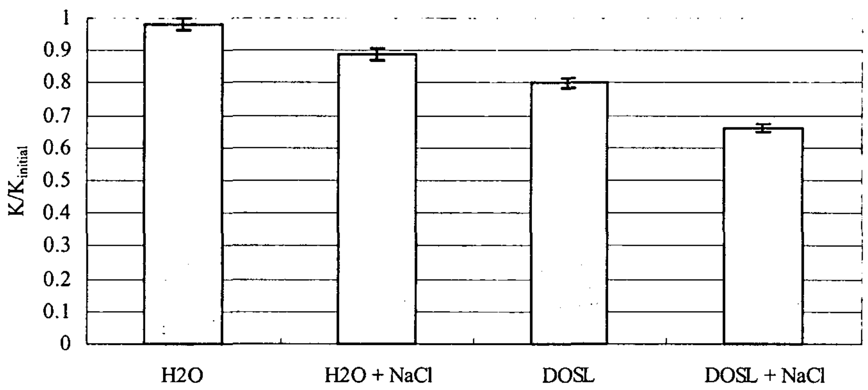

Fig. 1 Fraction of hydraulic conductivity relative to initial values after leaching with three pore volumes of control or surfactant solutions

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