Evaluation of Bioaugmentation with Entrapped Degrading Cells as a Soil Remediation Technology

Soil augmentation with microbial degraders immobilized on carriers is evaluated as a potential remediation technology using a mathematical model that includes degradation within spatially distributed carriers and diffusion or advection-dispersion as contaminant mass transfer mechanisms. The total volume of carriers is a critical parameter affecting biodegradation performance. In the absence of advection, 320 and 20,000 days are required to mineralize 90% of the herbicide linuron by Variovorax sp. SRS16 encapsulated in 2 mm beads with 5 and 20 mm spacings, respectively. Given that many pesticide degraders have low intrinsic degradation rates and that only limited carrier to soil volume ratios are practically feasible, bioaugmented soils are characterized by low effective degradation rates and can be considered fully mixed. A simple exponential model is then sufficient to predict biodegradation as verified by comparisons with published experimental data. By contrast, the full spatially distributed model is needed to adequately model the degradation of faster degrading contaminants such as naphthalene and benzene which can be mass-transfer limited. Dimensionless Damköhler numbers are proposed to determine whether the spatially distributed model is required. Results show that field-scale applications of immobilized degraders will be limited by the amount of carriers required to reach acceptable degradation rates.

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