Problem Set 6

Design of a Prepared-Bed Bioremediation System

Diffusivity of oxygen in soil is given below for soil taken from a prepared-bed system.

DGs (cm2/min)	Moisture Content by weight (%)
3.6	0%
3.0	10%
1.2	15%

An equation based on Fick's law combined with continuity of mass can be used in the design of prepared-bed soil bioremediation systems:

$$\frac{2\,DGs\,(Co - CG)}{R} = L^2$$

where D_Gs is the soil diffusivity coefficient, C_G is the lower limit of allowable oxygen in soil (% oxygen) for aerobic biodegradation, Co is the atmospheric O_2 concentration by volume, R is the rate of oxygen utilization within the contaminated soil, and L is the soil depth. The value of R must be determined for the specific soil. A typical value for R for newly applied contaminated soil is 1 x 10-2 $\%O_2$/min. Use the following boundary conditions for the design of a prepared-bed:

O_2 uptake rate (R) ($\%O_2$/min) = constant	$0 \le x \le L$
Soil $\%O_2$ = Surface %O2	$x = 0$
$dC_G/dx = 0$	$x = L$
Soil gas diffusivity (D_Gs) = constant	$0 \le x \le L$

Determine:

(1) The diffusivity of O_2 in air (cm^2/min)

(2) Design the depth of a lift of soil that can be added to the bed and undergo aerobic biodegradation if the soil is maintained at 80% of field capacity. Moisture content (% by weight) at 15 bar is 5.5% and at 1/3 bar is 12.5%.

(3) Determine the sensitivity of the depth of a lift to: (1) moisture content, and (2) the value of R. Use values of R that have been experimentally determined for Soil Bioventing. You design a graph or more than one graph to illustrate the effects of the variables moisture content and R on the depth of a lift. Think carefully about your graph.

(4) What additional factors, besides moisture content, would affect the value of D_Gs within a contaminated soil system treated by prepared-bed bioremediation or soil bioventing? Be specific and support your answer with references and logic.