AXIAL DISPERSION OF POLLUTANTS THROUGH POROUS MEDIA

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by

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SINCERELY DEDICATED

TO

MY LOVING MOTHER

C E R T I F I C A T E

This is to certify that the thesis entitled 'Axial Dispersion of Pollutants Through Porous Media', submitted by Mr. V. Viswanadham to the Indian Institute of Technology, Delhi, for the award of Degree of DOCTOR OF PHILOSOPHY is a record of the bonafide research work carried out by him.

Mr. V. Viswanadham has worked under my guidance for the submission of this thesis, which to my knowledge has reached the requisite standard.

The thesis or any part thereof, has not been submitted to any other University or Institution for the award of any degree or diploma.

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(ABSTRACT)

Dispersion of pollutants through porous media is a phenomenon of increasing interest to the current environmentalists, because of the prospect of recharging the ground water with sewage effluents, taking advantage of the treatment potential of the soil matrix, thereby solving both the sewage disposal problem as well as the water and material imbalances in the local ecosystems. However, the dispersion phenomena are too complex for a single comprehensive study and hence there is a need for the development of solutions for hypothetical idealized components of the original complex problem. Towards this end, axial dispersions, of sodium chloride (conservative pollutant) and potassium orthophosphate, (non-conservative pollutant) through homogeneous saturated porous media, have been investigated in these studies, considering some complex initial and boundary conditions, not generally amenable to analytical solutions, namely, the cessation of pollutant input during a steady state and the consequent concentration decay rate, input of pollutant at unsteady rates and dispersion through two layered media.

The analytical solution for instantaneous injection has been adapted to obtain pulse technique solutions, for the various cases mentioned above. By comparing with the results of experimental simulation, the pulse technique solutions,

developed in these studies, have been proved to be simpler and more accurate than the numerical and available analytical solutions.

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CONTENTS

NOTATIONS*

Symbol	Meaning	Dimensions
a	Adsorption coefficient	T^{-1}
a,b	Coefficients in eqn. 3.31 as defined there under (For a, context is clear enough to preclude confusion).	
c or C	Concentration of the pollutant, mass/mass in case of NaCl and ppm in case of KH_2PO_4	-
c_o or C_o	Initial concentration of the pollutant at the source of injection.	-
c_o' or C_o'	Initial concentration of the various pulses in the variable input case	-
$c_{(x,t)}$	concentration at any distance x cm and t sec.	-
D	Longitudinal dispersion coefficient	L^2T^{-1}
D_x, D_y, D_z	Dispersion coefficients in the X,Y,Z directions respectively	L^2T^{-1}
De	Equivalent dispersion coefficient for layered media	L^2T^{-1}
d_{50}	The particle size of porous medium for which 50% of the particles, by weight, are finer	L
ℓ	Thickness of any porous medium layer	L
ℓ_1, ℓ_2	Thickness of the first and second layers respectively	L
M	Equivalent mass of injection in a pulse of discretization, per unit area of the column.	M
n	Coefficient in eqn. 3.5 as defined there under.	-
P	Peclet number defined by eqn. 3.29	-

*Not applicable for Chapter II

NOTATIONS (Contd....)

Pe	Equivalent Peclet number for the combined layers.	-
P_1, P_2	Peclet numbers of the first and second layers	-
Q	Rate of flow through the experimental model	L^3T^{-1}
q	Volumetric rate of injection of the pollutant	L^3T^{-1}
t	Time	T
Δt	Time increment	T
u	Pore velocity of the fluid (gross velocity/porosity) in the axial direction.	LT^{-1}
u_r	Representative pore velocity of the combined layers	LT^{-1}
u_1, u_2	Average pore velocities of the first and second layers of the porous media	LT^{-1}
u,v,w	Average pore velocities in X,Y and Z directions	LT^{-1}
U_c	Uniformity coefficient of the porous medium	-
x	Distance of point of observation from the point of injection of pollutant	L
Δx	Space step; also discretized pulse size	L
x,y,z	Cartesian cordinates	L
α	Coefficient in eqn. 3.5 as defined there under. Also, the coefficient in eqn. 3.7 as defined there under (context is clear enough to preclude confusion).	
α'	Dispersivity of the porous medium in the axial direction	L
r	Pollutant input rate constant in the variable input case.	

NOTATIONS (contd....)

σ	Porosity of the porous medium	
ρ	Density of the fluid	ML^{-3}

Abbreviations:

CNA	Crank Nicholson Approximation
IBT	Inverse Breakthrough
TDM	Tridiagonal Matrix
Sand B	Badarpur Sand
Sand J	Jamuna Sand.

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