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Evaluation of Ogata-Bank Equation Solution for One-Dimensional Soluble Contaminants Transports in a Geologic Porous Medium

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***Abstract**: There are numerous equations which are often used to determine subsurface contamination arising from soluble transport in a homogenous, isotropic and saturated geologic porous medium. Several equations are readily available to address the contaminant soluble transport in a porous medium under a specified domain of space which usually range from zero to infinity. Fundamentally, the available criteria for applicability of the solution in analysing experimental data. The performance of the equation is hereby evaluated for retardation and dispersion coefficients of the contaminants between solid –liquid phase*

***Keywords**: Contaminants, Soluble Transport, Advection-Dispersion Solid –Liquid Phase*

INTRODUCTION

Several literatures have attempted to address the concept of Advection- Dispersion equation to evaluate subsurface migration of contaminants in a homogenous, isotropic and saturated geologic medium. Considering the flux of contaminants into and out of a fixed representative chemical volume and analysing same using the principles of conservation of mass to the elemental volume ,the one –dimensional equation can be used to estimate the level of contaminants concentration taking into cognisance the following assumptions which includes that the medium must be homogenous and isotropic ,the contaminants is soluble in the moving fluid, the density and velocity of the fluid is incompressible ,the coefficient of the molecular diffusion and mechanical mixing are additive to give hydrodynamic dispersion coefficients and the velocity is macroscopically uniform.

Besides, sorption – desorption is the instantaneous and reversible portioning of chemical species between the aqueous solid surface of a porous medium. If the phenomena are considered as only reaction occurring in the system and the processes, such a process was described by linear Freudilich isotherm. Most studies use 50% concentration point on the concentration profile of the retarded contaminants as retarded advocative velocity of the contaminants. Consequently, retardation factor determined by batch experiments are greater than those determined by the column experiments in most cases. Selected aspects of the Ogata-Bank analytical solutions to the advection –dispersion equation may contribute greatly to incorrect evaluation of R used in most procedural cases experiments.

THEORITICAL DEVELOPMENT

An analytical solution for contaminant transports in a porous medium was proffered by Ogata using the Laplace transformation technique given as:

C/Cx=1/2erfc(Rx-Vt/2vDRt) +1/2 erfc(Vx/D) erfc (Rx+Vt/2vDRt) ………. eqtn (1) for a given boundary condition

C(x,0) =0., x>0., C (0, t) =Cα t>/=0 and C(α,t,t)=0.,t=0

Where

erfc is the complimentary error function and R is the retardation factor given as

R =1+pdry/n kd

Dividing equation (1) by **Cxh. Xx**^{2}h where it represents characteristic concentration and Xh represents characteristics length and rearranging the dimensionless form of equation (1) gives

OC/OT =d^{2}C/ dx^2=Pedc/dx

Where **C =C/Ch** representing normalised concentration

Analytical solution is definitely dependent on the formulation of a boundary condition. The contaminant solution of concentration C is applied at specified time displacement column experiments at a rate from a perfectly mixed inlet reservoir to the inlet surface of a porous medium, mass conservation across the inlet boundary leads directly to flux type boundary conditions.

APPLICATION OF SOLUTION TO LABORATRORY EXPRIMENTS

A contaminated solution of known concentration C is continuously fed to the upstream end of a column packed with a homogenous geologic porous medium and the contaminant concentration at the downstream end of the column is kept at zero by flushing with clean water .The concentration profile of the chemical species after a specified duration is determined by sectioning the porous medium in the column and performing chemical analyses for each section or by in-situ measurement using techniques appropriate for specific chemical species .if the length of the column is taken at the characteristics length ,then the dimensionless boundary conditions and initial conditions of experiments differs greatly as earlier observed. Theoretically speaking, the dimensionless ogota analytical solution should not be used to analyses experimental data in a typical type of column test and as such a different analytical or numerical solution satisfying the boundary and initial conditions should be developed.

However, numerical solution can be readily obtained from commercially available equation solvers. Hence, it is worthwhile to investigate the applicability of analytical solution proffered in this paper.

EFFECTS OF RETARDATION FACTORS FOR CONTAMINANTS.

Most of the retarded advective velocity is widely used to determine the retardation factor. The retarded velocity of contaminants is generally given by **V/R** in a controlled column experiment, the seepage velocity of the moving fluid is known. if the retarded advective velocity of a contaminant can be determined readily. The most widely adopted method is to use the velocity *of C/Co* =0.50points as the retarded advective velocity of the contaminant. The velocity of **C/Co =0.50** points can be determined from the breakthrough curve of the chemical species in a given column.

In the dimensionless parameter given as

$$(V/R)/(x/t) = Pe/XT.$$

The concentration profile of the contaminants along the column length can be determined from selected value of t (or T) of the breakthrough curve and can be determined over a period of contaminant solution percolation.

DETERMINATION OF THE EFFECTIVE POROSITY OF A GEOLOGIC MEDUIM

The discharge velocity or Darcy velocity of fluid through a porous medium V is related to the corresponding seepage velocity, **V by Vt /n**

Where,

n=porosity of the medium. However, since not all porous medium may be interrelated, n should be the effective porosity rather than the total porosity. Effective porosity is therefore defined as the percentage of interrelated pore space of a porous medium .it may be difficult to use conventional geotechnical engineering methods to determine effective porosity of a geologic porous medium since must methods do not differentiate interconnected pores and unconnected pores. A column test using a non-reactive soluble tracer is a useful method to measure the seepage velocity of fluid through a porous medium. As the Darcy velocity can be measured readily by the effective porosity. For a non-reactive tracer, the retardation factor is always unity.

CONCLUSION

The analytical solution to advective –dispersion equation developed by Ogata has being widely used in ground water contamination studies. Column experiments are often performed to study the interaction between the contaminant and the geologic porous medium, depending on the imposed boundary conditions n and assumptions, the solution is applicable to the analyse of experimental data collected from different column. These assumptions and applicability were thoroughly reviewed.

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