Experimental Study of Contaminant Transport through Porous Media

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ABSTRACT

A 15m long column was taken having a diameter of 15.24cm.The column was filled with different type of materials like coarse sand, fine sand, natural soil, silt and gravels periodically. The heterogeneous soil column gradually changed, on average, from coarse-textured at one end to fine-textured at the other end and contained layered, mixed and lenticular formations of various shapes and sizes. A series of experiments were conducted to investigate the solute transported in this 15m long column, horizontally placed soil columns during steady saturated water flow. Additionally for the first time these experiments were carried out in such a large column. NaCl breakthrough curves (BTC's) in the columns were measured with the help of electrical conductivity probes inserted at 3m intervals. Only pulse type boundary condition, considered in the experiments .The BTC's observed were very irregular, non-sigmoidal and exhibited extensive tailing. Velocity variations in the heterogeneous medium were found to be much larger. Values of the dispersivity, a = D~ff/veff, for the heterogeneous column were as high as 200 cm. The dispersivity for transport in both columns increased with travel distance or travel time, thus exhibiting scale dependency. The heterogeneous soil column also showed the effects of preferential flow i.e., some locations in the column showed earlier solute breakthrough than several locations closer to the inlet boundary. Spatial fluctuations in the dispersivity could be explained qualitatively by the particular makeup of the heterogeneities in the column.

Keywords: Advection, Dispersion, Sorption

1. INTRODUCTION

Ground water Contamination is the detrimental alteration of the naturally occurring chemical, thermal, physical or biological quality of groundwater. The movement of contaminants is difficult to predict. Chemical quality of ground water is mainly affected by presents of contamination or soil pollution. Ground water can become contaminated from Point source pollution that comes from a single source, such as a factory or wastewater treatment plants. Non-point source pollution comes from the cumulative effect of a region's residents going about their everyday activities, such as fertilization, surface runoff, pesticides, pet waste, motor oil, and household hazardous wastes .Sometimes leaching of wastes from land fills or discharge of industrial wastes to the soil without treatment also effects ground water. Many substances found naturally in rocks or soils like iron, manganese, arsenic, chlorides, fluorides, sulfates, or radionuclides is dissolved in ground water. If once ground water affected by contaminat it is difficult and expensive to clean up. Different type of contaminant have different transport properties and depend on the size of grain of porous medium .Laboratory experiment are perform to understand physiochemical reaction take place for a particular set of solute and porous medium. The main objective of Experiments performed are to investigate solute transport in long, horizontally placed soil columns under fully saturated condition. Soil columns are used in experiment column is heterogeneous, containing layered, mixed, and formations of different shape and sizes of lenses. Solute transport in soil and groundwater is affected by physical and chemical properties. The physical properties are dispersion and diffusion; chemical properties are sorption. Dispersion is a key process controlling transport of solute in porous medium. It occurs under the influence of spatially varying velocity and microscopic diffusion, although natural conditions “in the field” normally involve temporal dependence on velocity. Functions that describe solute behavior are typically defined under steady-state conditions. Dispersivity is also defined as the ratio of dispersion coefficient to the effective pore water velocity. Dispersivity of a heterogeneous aquifer at first grows more or less linearly with the solute residence time and travelling distance. An important aspect in understanding the solute transport processes through porous medium is convection-dispersion equation (CDE), generally employed spatially and temporally. But it is found that the CDE cannot describe the transport phenomenon completely due to the scale dependent nature of dispersivity. Incorporation of scale dependent dispersion function is used with CDE to understand the effect of field scale heterogeneity.

2. OBJECTIVE OF THE STUDY

1) To understand spatial and temporal behavior of breakthrough curves of experimental data of reactive and nonreactive solute by conducting long soil column experiments.

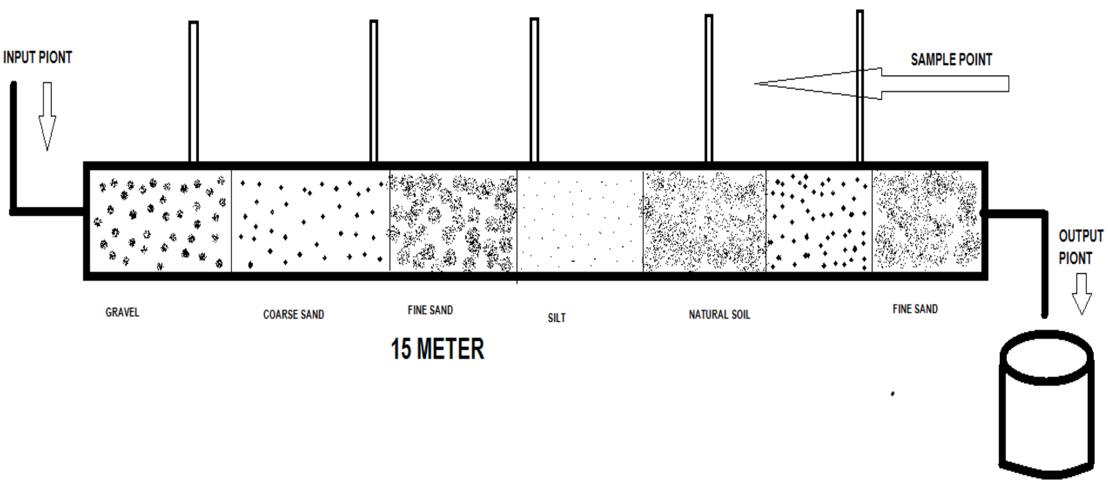
2) To study and calculate the transport parameter through simulation of experimental breakthrough curves.

- Literature review
- Huang et al. (2011)Investigated the sensitivity of flow and solute transport highly heterogeneous and non- stationary random permeability fields. Two parameters, namely the width parameter (C) and the Levy index (α), were varied systematically to examine their effect on resulting permeability, flow velocity and concentration fields. larger C and smaller α both

led to more heterogeneous permeability and velocity fields and created sharper leading edges and wider tailing edges of solute plumes

- Leij et al. (2012) Described solute transport in structured or layered porous media with different nonzero flow rates in two distinct pore domains with linear solute transport between them.With The help of solution of DADE illustrate how differences in pore water velocity between the domain and low transfer rates will lead to double peaks in the volume averaged concentrated profile versus time.

3. EXPERIMENTAL SET-UP



4. EXPERIMENTAL PROCEDURE

Experimental set-up consists of heterogeneous sand columns. The length of the column is taken 15 m and diameter of the column is 15.24cm. The heterogeneous column is filled with different type of materials including coarse sand, fine sand, natural soil, silt and gravels in periodical layers. 300 liter of storage tank in which solution is made was placed near to the column.

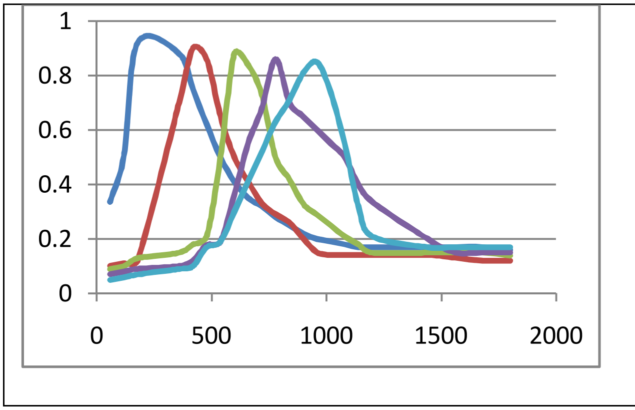
The experiments are conducted on using heterogeneous soil columns. contained negligible organic content. For sample collection at regular intervals entire Column length was divided in 5 equally distributed distances of 3metre. After that the column were saturated slowly by flowing tap water continuously for 24 hrs. The head gredient was introduced by maintaining varying head at input, while keeping output head constant. For input a solution of 300 liter of predifined concentration of contaminant was prepared in the storage tank. Solution was introduced in the column. Several sets of samples were collected at 1hr interval. After collection of samples testing procedure as followed for chloride and fluoride. Chloride testing was done by silver nitrate titration method. In the titration method 50ml volume of sample is taken and 1ml potesium chromate indicator was mixed, then titrated with silver nitrate till red brick color appered. Fluoride testing was done by using spectrophotometer method. In the fluoride testing, 10ml volume of sample taken in small vials and mixed with 2ml SPADNS solution then vials are inserted in spectrophotometer and the absorbance is observed.Then absorbance is converted into cocentration by standard absorbance-concentration plot.Pulse type boundary condition, only was consideres in experiments.

5. ANALYSIS OF DATA-

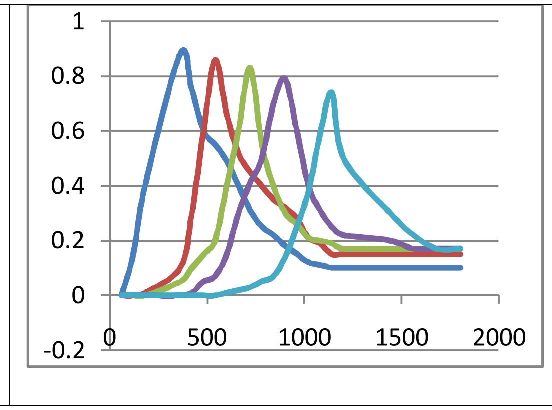
Table 1. Observed data of chloride and fluoride through heterogeneous soil column (Constant concentration type boundary condition)

Time (mnts)	Conc Mg/l 1(3m)	Conc. Mg/l 2(6m)	Conc. Mg/l 3(9m)	Conc. Mg/l 4(12)	Conc. Mg/l 5(15m)	Time (mnts)	Conc Mg/l 1(3m)	Conc Mg/l 2(6m)	Conc Mg/l 3(9m)	Con Mg/l 4(12)	Conc. Mg/l 5(15)
60	0.336	0.1	0.09	0.07	0.05	60	0	0	0	0	0
120	0.504	0.11	0.1	0.08	0.06	120	0.15	0	0	0	0
180	0.92	0.12	0.13	0.09	0.07	180	0.4	0.01	0	0	0
360	0.88	0.7	0.15	0.1	0.09	360	0.88	0.1	0.05	0	0
420	0.75	0.9	0.18	0.12	0.1	420	0.75	0.3	0.1	0.01	0
480	0.62	0.86	0.21	0.177	0.17	480	0.6	0.6	0.15	0.05	0
540	0.5	0.65	0.5	0.19	0.19	540	0.55	0.86	0.2	0.07	0
600	0.41	0.5	0.88	0.36	0.3	600	0.49	0.66	0.4	0.15	0.01
660	0.35	0.41	0.84	0.55	0.41	660	0.4	0.52	0.6	0.3	0.02
720	0.32	0.33	0.73	0.68	0.52	720	0.31	0.45	0.83	0.41	0.03
780	0.28	0.29	0.5	0.86	0.63	780	0.25	0.4	0.55	0.5	0.05
840	0.25	0.26	0.42	0.7	0.71	840	0.22	0.35	0.4	0.7	0.07
900	0.22	0.2	0.33	0.65	0.808	900	0.18	0.32	0.3	0.79	0.14
960	0.2	0.15	0.29	0.6	0.848	960	0.15	0.28	0.26	0.6	0.25
1020	0.19	0.14	0.25	0.55	0.736	1020	0.12	0.21	0.21	0.4	0.38
1080	0.18	0.14	0.21	0.5	0.55	1080	0.11	0.19	0.2	0.31	0.59
1140	0.17	0.14	0.18	0.4	0.32	1140	0.1	0.15	0.19	0.25	0.74
1200	0.17	0.14	0.15	0.336	0.21	1200	0.1	0.15	0.17	0.22	0.5
1440	0.17	0.14	0.15	0.2	0.17	1440	0.1	0.15	0.17	0.2	0.3
1560	0.17	0.13	0.15	0.15	0.17	1560	0.1	0.15	0.17	0.17	0.22
1680	0.17	0.12	0.15	0.15	0.17	1680	0.1	0.15	0.17	0.17	0.17
1800	0.16	0.12	0.14	0.15	0.17	1800	0.1	0.15	0.17	0.17	0.17

Break through curves of experimental data of chloride and fluoride in Heterogeneous soil column experiment



chloride



fluoride

6. RESULTS

(i) In this study the transport of conservative solute (NaCl) at different distances has been observed.

(ii) Each of the output points was used to analyze the behavior of BTC's at different distances simultaneously.

(iii) The observed BTC's for heterogeneous column were smooth.

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