Modelling of Solute Transport through Saturated Porous Media: Experimental and Numerical Approach

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Declaration by the Research Scholar

This is to certify that the Thesis entitled **"Modelling of Solute Transport through Saturated Porous Media: Experimental and Numerical Approach",** submitted by me to the Indian Institute of Technology Mandi for the award of the Degree of Master of Science (by research) is a bonafide record of research work carried out by me under the supervision of ***Dr. Deepak Swami.*** The content of this Thesis, in full or in parts, have not been submitted to any other Institute or University for the award of any Degree or Diploma.

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Declaration by the Research Advisor

This is certify that the Thesis entitled **"Modelling of Solute Transport through Saturated Porous Media: Experimental and Numerical Approach",** submitted by Ms. ***Chandni*** to the Indian Institute of Technology Mandi for the award of the Degree of Master of Science (by research) is a bonafide record of research work carried out by her under my supervision. The content of this Thesis, in full or in parts, have not been submitted to any other Institute or University for the award of any Degree or Diploma.

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ABSTRACT

Uncertainties and difficulties associated in tracer transport arising from heterogeneities of the aquifer material necessitates the importance of laboratory tracer experiments. To understand the effect of various aquifer material and associated complexities, tracer transport experiments were performed in fully saturated condition for glass beads, sand and natural soil. The mini-aquifer tank had inner dimensions of 150cm x 10cm x 50cm and eluded tracer was Sodium Chloride (NaCl). The materials were so chosen to gradually increase the heterogeneity from glass beads to natural Himalayan foothill field soil. The aim of the experimental investigation was to study contaminant transport for various porous materials consisting different physical properties and to compare non-reactive tracers breakthrough curves (BTC's). Another objective was to highlight the difference between the processes observed by model based on partitioning of porous medium in dual porosity and time random walk approach. Therefore, the simulation of the observed BTC's were carried out by using mobile–immobile model (MIM) and continuous time random walk (CTRW) model of solute transport. Observed experimental breakthrough curves depicted relatively Fickian and Gaussian diffusive spreading for homogenous glass beads in comparison to less heterogeneous sand, while natural soil exhibited the presence of preferential flow (physical non–equilibrium). Estimation of the transport parameters were done using Levenberg Marquardt optimization algorithm for MIM and MATLAB toolbox for CTRW. Estimated values of the parameters from both the models were compared to identify the differences in the estimation of the transport parameters. It was observed that the physical processes participating in relatively complex porous medium were captured well by MIM whereas CTRW found suitable for providing a better fitting. To demonstrate the importance of estimation of in situ porosity calculations, experimental BTC's were simulated for numerous porosity models which estimate porosity based on hydraulic conductivity and grain size distribution. The empirical formulae based estimation of porosity was found highly unreliable comparative to in situ porosity and was leading to inaccurate estimation of other transport parameters as Dispersivity, pore velocity etc. The study find its application in the correct estimation of the porosity along with other transport parameters for a range of homogeneous material to a complex Himalaya foothill field soil.

Keywords. *Breakthrough curves, MIM, CTRW, porosity models, Levenberg – Marquardt*

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