Advection and dispersion in homogeneous geologic media

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1 Introduction

The advection-dispersion equation (ADE) is widely used as the governing equation of the transport phenomenon of contaminants in groundwater. However, in recent years, it has pointed out that ADE does not reproduce the concentration distribution at a distant place from the source. Apparently, this is because of the characteristics of the dispersion coefficient D(=Alpha L x v (m2/s)), which depends on the distances. Here Alpha L is the dispersivity, v is the average liner groundwater velocity. The problem is Alpha L grows with scales. In the present study, we propose a new model without such scale dependencies, and thereby compare experiments with this model.

2 Experimental Setup

The equipment consists of a 1000mm x 120mm x 710(H)mm container, Marriott tank, a channel switching machine, amplifier, and PC. The container is filled by Toyoura sand (average particle diameter 0.175mm) by hydraulic falling method, and the trace is 3%NaCl solution. The head difference between the inlet- and the outlet tank is set to 5cm. The sensors are embedded at 15 locations in the sand, which monitor the concentration. We prepare two kinds of geologic media; one is a homogenous, and the other is heterogeneous. For heterogeneous medium, ten blocks, share 10% of the total volume of sand, were embedded in the sand layer. Their size were 100mm x 100mm x 40mm. The locations of these blocks are determined randomly.

3 Result

For the experimental results, we perform the following three analyses. (1) Scale dependency of Alpha L; (2) Mean square displacement; and (3) Fitting of the breakthrough curves. First, (1) were plot on log log graph sheet, as x axis is advection distance and y axis is alpha L This relational expressions were Alpha L = 8.4 x 10-5x-0.17 in homogeneous and Alpha L = 4.0 x 10-4x0.56 in heterogeneous medium. This means that the scale dependency of alpha L in homogeneous was smaller than that in heterogeneous and is different from Inoue et al.'s experiment result(2000). For (2), we calculated them directly from the breakthrough curves. In homogeneous medium, (L2) was proportional to t1.05 . In contrast, in heterogeneous medium, (L2) was in proportion t0.768. This means that the heterogeneous medium show a discrepancy from the normal diffusion. For (3), we found that ADE fits experimental results well in homogeneous medium, but not in heterogeneous medium. To summarize, the flows in homogeneous medium conforms to ADE, but does not in heterogeneous medium.

4 Conclusion

We found that the experiment results fit ADE in homogeneous media but does not fit in heterogeneous medium. In the presentation, we will present a comparison between the experimental breakthrough curves and the fractional advection-dispersion equation based on Benson et al.'s (1998).