A column test of heavy metal adsorption with comparison of the CTRW model

Yuto Kamio[1]; Yuko Hatano[2]

[1] Risk Engineering, Tsukuba Univ.; [2] Inst. Eng. Mech & Sys., Tsukuba Univ.

1. Purpose

Environmental pollution came to be recognized as an important problem. To predict the accurate concentration of pollutions and to understand a long-term behavior are necessary. Conventionally, advection dispersion equation(ADE) has been used for a prediction of the behavior of adsorptive pollutants in the soil. But it is not always appropriate as a model (e.g. field experiment by Adams and Gelhar[1]). Therefore, in recent years, a new governing equation, called continuous-time random-walk model (CTRW) is proposed. The effectiveness of this new model is confirmed in experiments that use tracers chloride ions and the bromide ions[2]. However, the experiments of adsorptive systems are rare. So, in this study, a column test has performed and the results compare with conventional ADE model to the CTRW model.

2. Theory

The CTRW is defined based on a one-dimensional random walk. The probability of existence of a random walker corresponds to the concentration of a pollutant. The particle leaves the origin and moves to the constant distance right or the left in probability p or q=1-p per unit time. CTRW model follows the distribution of time to stay at a site before a particle jumped. It is called as the waiting-time distribution P(t). Following a previous work[3], a discretization form is used as waiting time function,

$P(t)=Ct^{-A}$.

P(t) is probability density function. Constant C is decided by Riemann zeta function. The Monte Carlo simulation of this expression was compared with an experimental result. The value of A affects the anomality of the system. If A is greater than 3, the system exhibits essentially the same behavior as the normal diffusion equation, and if A is less than 2, the system is expressed very different from normal diffusion, called the anomalous diffusion. If A is greater than 2 and less than 3, the system is expressed mixed behavior of normal diffusion and the anomalous diffusion.

3. Experimental setup

A series of column test was performed to obtain diffusion behavior. Toyoura sand was filled in PVC pipe and heavy metal solution of 2ppm was injected with a constant flow rate. The discharge out of the column was collected every 30 minutes and the metal concentration was measured. Two times of experiments were performed and used one kind of heavy metal for one experiment. Zinc, lead were used as heavy metal, the break through curves are obtained. In addition, the drained sand layer was sliced every constant thickness, and the adsorbed quantity of heavy metal on Toyora sand was measured for each slice.

4.Conclusion

Break through curve is described the data of the column test, and performed fitting with ADE and CTRW model. We show the result that simulated by CTRW model in figure 1. The cross axis expresses the numbers of the steps corresponds to time, and the vertical axis expresses the numbers of heavy metal concentration in discharge. The figure changed values of A. As A becomes small, characteristic of the anomalous diffusion appears significantly. Normal diffusion is expressed with A=3.

On the conference, I report the details of the fitting of the experimental value by the CTRW model and ADE, and show that the behavior of the pollutant in soil is almost anomalous diffusion.

1)Adams,E.E,and L.W.Gelhar.:Field study of dispersion in a heterogenous aquifer,2,spatial moment analysis,Water Resour.Res.,Vol28(12 3308,1992.

2)Margolin, Gennady ; Dentz, Marco ; Berkowitz, Brian: Continuous time random walk and multirate mass transfer modeling of sorption ,Chemical physics. 295, no. 1, 2004

3)Monte Carlo simulation and date analysis of anomalous diffusion of the continuous time random walk model,Y.Hatano,N.Hatano,in preparation