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A column test of adsorptive material and study of parameter setup of CTRW

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1. Purpose

Recently the problem of ground water pollution has become more serious because of the environmental law institution and the social situation. When we manage the risk from soil pollution and apply the technology to remediate the polluted soil, to predict exactly the accurate concentration of pollutions and to understand a long-term behavior are necessary from engineering and economical view. Conventionally, advection dispersion equation(ADE) has been used for the prediction, but it is not always appropriate as a model (e.g. field experiment by Adams and Gelhar). The points at the issue are that the behavior has the tailing that he concentration profiles have a low concentration part for a long time and dispersion coefficient depends on the distance from the source. These phenomena are called anomalous dispersion and it has unsolved problems about adsorptive pollutions. Therefore, in this study we focused on how heavy metals disperse and adsorb and conducted the column experiment about adsorptive materials. In addition, we gave consideration dates obtained from these experiment using Continuous-Time Random-Walk model (CTRW) with conducting the fitting.

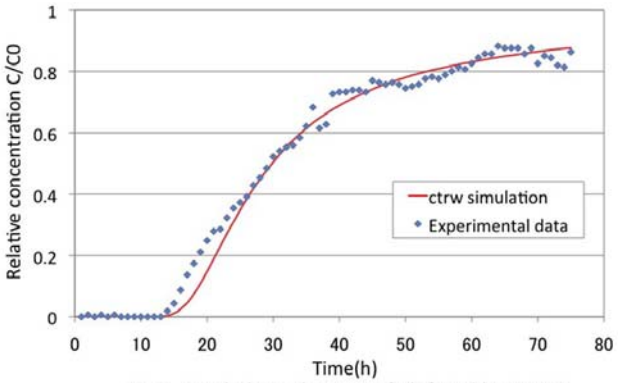

Fig 1. Break through curve of Pb fitted by CTRW

2. Theory

CTRW is proposed as a new governing equation that can express the anomalous dispersion. The validity of the model has been estimated in chloride ions and bromide ions. The probability of existence of a random walker corresponds to the concentration of a pollutant. CTRW model has the distribution of time to stay at a site before a particle jumped as the heterogeneous distribution. It is called as the waiting-time distribution P(t), is the probability per unit time of the particle which just arrives at site x at time t, P(x,t) is the probability that distance x jumps after waiting time t. In this study, the x-dependence is neglected and expressed as P(t). Following a previous work [1], a discretization form is used as waiting time function,

$P(t)= At^{-a}$

P(t) is probability density function, so constant number A is standardized. In the case of a>3, the system exhibits essentially the same behavior as the normal diffusion equation, and in the case of a <2, expressed very different from normal diffusion. In the case of 2<a<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 non-adsorptive tracer and adsorptive material were injected with a constant flow rate. The discharge out of the column was collected at regular time intervals and the material concentration was measured. Zn and Pb were used as adsorptive tracer, NaCl was used as non-adsorptive one.

4. Conclusion

Break through curve is described the data of the column test, and performed fitting with CTRW model. For the adsorptive materials, we got the date of the tailing that is a characteristic of the anomalous dispersion. We show the result fitted by CTRW model to column experiment using a Pb solution in figure 1. That model could accurately follow the result. Although differences of the strength of anomalous dispersion are found, CTRW model showed the good prospect to apply to predict the dispersion of contaminants.

We found that there are two causes of anomalous dispersion, the heterogeneous of flow pass and the strengths of adsorption. The heterogeneous of flow pass means the retardation caused by the distributions of porosity, is depended on the density of the soil bed, and of flow velocity. Meanwhile, the heterogeneous of adsorption is caused by the strength of adsorptive potentials and the hydolaulic conductivity or the elimination in the flow. In addition, we found that the ratio that causes heterogeneous differs between the pollutants.

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

Keywords: soil pollution, anomalous transport, continuous time random walk, adsorption, heterogeneity, heavy metal