EFFECT OF SINUOSITY ON HYPORHEIC EXCHANGE IN NATURAL STREAMS AND RIVERS

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The hyporheic exchange mechanisms associated with the hyporheic zone of a natural heterogeneous environment are often modified by the unsteady behavior of the free-flowing water zone. This can play a very important role in the mass exchange between the free flowing water zone and hyporheic zones which are cause of secondary hump and plateau region of the tail of observed breakthrough curve in natural streams. In this work, an analytical solution is used to predict the shape of solute breakthrough curves in a natural stream based on various representations of transient storage exchange, including new parameter formulations.

A nonlinear multi-variable minimum covariance determinant regression method was used to estimate the key dimensionless parameters. These parameters were identified from dimensional analysis and include the channel sinuosity, the Peclet number, the friction factor, the sinuosity, and the width-to-depth ratio. The regressions also used fifty-eight data sets measured in thirty-four natural streams in the United States that were collected from published reports. In this study, regression coefficients were estimated by using the robust minimum covariance determinant regression method. The new regression equations thus derived are given as

$$\mathrm{P} = \alpha\left(\frac{W}{h}\right)^{\beta}\left(\frac{U}{U_*}\right)^{\gamma}\left(\frac{UL}{K}\right)^{\delta} S_i^{\lambda} \qquad (1)$$

in which P represents any of key parameters of Eq. (1) and α, β, γ, δ, and λ are coefficient given in Table 1. The correlation coefficients for the fit are also summarized in Table 1. In this study, regression coefficients were also computed by using the least squares method, and those values were used as an initial condition for the solution of the robust minimum covariance determinant regression method.

Table 1. Range of Dimensionless Variables

Dimensionless Data	Parameters					Correlation Coefficient
	α	β	γ	δ	λ	
K_f / hU_*	43.928	0.845	0.2176	-0.042	-0.689	0.89
$T / (h / U_*)$	20.595	-1.463	0.6639	0.323	1.9132	0.81
ε	0.8279	-0.355	-0.259	-0.276	0.3315	0.92

The data used herein for model evaluation were obtained from an experiment conducted in the Shingobee River, which is small unpolluted cobble-bed pool-riffle stream located in Hubbard county, Minnesota, USA. The Shingobee River flows northward through a 3-4m-wide and 0.3-0.6m-deep channel and the channel slope is 0.00008. The length of the total study reach is 1180 m downstream of the injection site with stations 1, 2, 3, and 4 located 165, 293, 580, and 1180m downstream of the injection site, respectively. Stream discharge along the study reach was $0.011 m^3/s$. The experiment consisted of a slug injection of a solution was chloride (conservative solute; Cl^-). To estimate the key parameters, the proposed empirical equations were also used to estimate these parameters of the hyporheic zone stochastic model. Overall the proposed model describes well an intermediate range of transient storage zone residence times along this small river. The analytical solution of the hyporheic zone model was applied to simulate tracer concentrations in the main channel based on hyporheic exchange with the transient. Overall, we obtained a good fit between measured and simulated time-concentration curves based on visual comparison (Fig. 1)
for four modeled reaches.

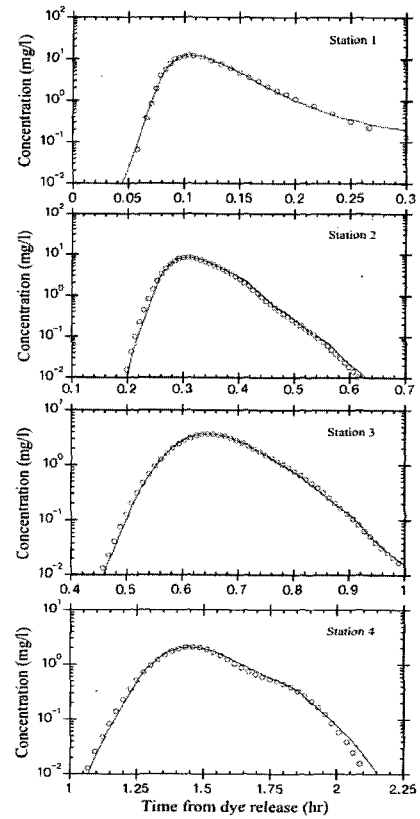

Fig. 1 Measured and simulated dye concentrations from the lower Shingobee River.