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ESTIMATION OF THE EMPIRICAL MODEL PARAMETERS GOVERNING LONGITUDINAL DISPERSION COEFFICIENT IN 1D STREAM FLOW USING STATISTICAL METHODS

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Abstract

The objective of this study is to find the values of the empirical parameters of a functional relationship for the longitudinal dispersion coefficient (D) in 1D open channel flow, in order to have the best prediction of waste concentration and propagation in a long well mixed estuary. Linear and non-linear regression and Bayesian inference are employed for the estimation of the model parameters α, b and c, using field data. The paper compares simulated and actual dispersion coefficients and evaluates model accuracy by using statistical measures such as R-squared, Mean Absolute Error (MAE), Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC), and Log-Likelihood. The results prove the capability of statistical models in accurately representing the degree of dispersion in real-world channels. The OLS regression model has α of 0.1045, b of -0.26275, c of 1.38056, and R2 of 0.682. The model fits well, however there are no strong predictors. This is probably because the sample size is limited and there may be multicollinearity. The nonlinear regression analysis, based on data observations, produced optimal parameter estimates of α = 0.015914, b = 1.299749, and c = 1.361944. The model demonstrated a coefficient of determination (R^2) of 0.83, indicating a strong agreement between predicted and observed dispersion coefficients. Bayesian Inference gave coefficient estimates with confidence intervals. The c variable is the most important, followed by alpha, while b may be statistically insignificant because its confidence interval includes 0. The model is stable, as evidenced by R_hat (Gelman–Rubin diagnostic) ≈ 1 and high ESS (Effective Sample Size) values. The differences between the real and predicted D from the Bayesian model are reasonable, indicating a good fit to the model.

Keywords: Longitudinal Dispersion, Empirical Model, Bayesian Inference, Curve Fitting, Nonlinear Regression, Open Channel Flow.

1. INTRODUCTION

One dimensional (1D) advection dispersion equation is widely used in water quality modelling in rivers (M. Mawat & A. N. Hamdan, 2023; Mawat & Hamdan, 2024a; Zeng & Huai, 2014). The longitudinal dispersion coefficient (D) is one of the important parameters in this case, which describes the dispersion of a solute in the longitudinal direction as a result of the processes of advection and diffusion (M. J. Mawat & A. N. A. Hamdan, 2023a).

The longitudinal dispersion coefficient is an important variable that must be known in predicting the fate and transport of contaminants in natural and open channels (Mawat, 2025). This coefficient is affected by a number of hydraulic variables including, depth, channel width, shear velocity, and mean flow velocity. Several analytical and statistical techniques have been derived and used to provide an accurate prediction of this coefficient (Baek & Seo, 2013), according to the type of data and flow conditions, where each has its advantages and disadvantages.

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