Applying Generalized Additive Models to Predict Benthic Macroinvertebrate Diversity in Relation to Water Quality: A Case Study, Mawarala Stream, Sri Lanka

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Abstract

Freshwater ecosystems harbor exceptional biodiversity, yet they remain highly sensitive to changes in physical and chemical conditions, making continuous monitoring essential for evaluating their ecological health. Benthic macroinvertebrates have been identified as suitable bio-indicators because they exhibit varying degrees of sensitivity to different environmental stressors, and they are specific to habitats. In this study we assessed the relationship between water quality physicochemical parameters and the diversity of benthic macroinvertebrates found in the Mawarala Stream located in Southern Sri Lanka. Water quality parameters that we monitored included temperature, pH, dissolved oxygen (DO), biological oxygen demand (BOD), electrical conductivity, total dissolved solids (TDS), total suspended solids (TSS) and nitrates selecting four sites of the stream. A total of sixteen macroinvertebrate families belonging to nine orders were recorded. Hydropsychidae, Dermestidae, and Simuliidae were the most abundant families, whereas Aeshnidae, Paludomidae, and Corydalidae occurred in low abundances. Correlation analysis revealed a strong negative correlation between TSS and diversity ($p < 0.05$); pH, DO and temperature had weak, non-significant correlations. A multiple regression model ($R^2 = 0.27$) was insufficient to accurately explain the complex ecological patterns; therefore, a generalized additive model (GAM) was developed using TSS, DO, and pH as predictor variables, while temperature was removed due to statistical non-significance. The final GAM provided an improved fit to the observed data (adjusted $R^2 = 0.627$; deviance explained = 69.6%) and yielded a lower Akaike Information Criterion value (AIC = 70.39). The predictive capability was thought to be limited due to both the small sample size and large ecological variability. Overall, the study emphasizes how TSS, DO, and pH affect the diversity of macroinvertebrates and supports the use of GAMs in tropical freshwater bioassessment. It also highlights the need for larger datasets to improve the predictive accuracy of streams in Sri Lanka.

Keywords: Benthic macroinvertebrates, freshwater ecology, Generalized Additive Model, Shannon-Wiener index, water quality