Evaluating the link between nutrient concentration, periphyton growth rate, stream photosynthesis, and biological indicators of ecosystem health in streams in Tennessee, Alabama, and Virginia

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Abstract
Recent Federal and State initiatives to establish quantitative criteria for stream eutrophication have intensified the search for inexpensive and reliable field measurements that indicate trophic status of the biological community, indicate the cause of impairment, and provide for comparative evaluations between streams. The field measurement most often used to characterize both trophic status and cause of impairment – instantaneous nutrient concentration in the water column – does not correlate consistently with results of ecological assessments of trophic status, especially for periphyton-dominated streams. In this study, chemical and ecological data sets from eight intensively studied stream sites (watershed area ranging from 30 to 170 square miles) in seven level IV ecoregions were combined to test correlation of three candidate indicators – nutrient concentration, periphyton growth rate, and stream photosynthesis – with trophic status of the biological community as quantified by the relative abundance of omnivorous taxa represented in the fish and benthic macroinvertebrate communities.

The median value of nitrate concentration during base flow (estimated from large data sets, $n > 20$ for each site) correlated positively but weakly with relative abundance of omnivorous benthic macroinvertebrates. The correlation between median value of nitrate concentration during base flow and relative abundance of omnivorous macroinvertebrates was strengthened to a significant level ($p < 0.005$) when median nitrate concentrations were adjusted by subtracting estimated background concentrations (quantified separately for each ecoregion using 75th percentile of nitrate-concentration data from minimally disturbed reference sites in each ecoregion). Variability in nitrate concentrations, however, weakens this indicator's reliability unless data from many samples collected throughout the year are available from which to estimate a median value of nitrate concentration. The requirement for a large data set reduces usefulness of this indicator for surveys of a large number of sites.

Periphyton growth rates during summer were measured at four of the eight sites to test whether growth rate is more stable than nutrient concentration over time and to test its correlation with trophic status of the fish and macroinvertebrate communities. Measured growth rates varied widely from week to week at each site; consequently, variation of growth rates among sites could not be correlated with variation in trophic status.

Rates of stream photosynthesis during spring and summer were estimated at four sites using a diurnal-curve method. Estimated rates fluctuated slightly with daily fluctuations in solar radiation, but otherwise remained relatively constant throughout a season despite fluctuations in streamflow or nitrate concentration. During spring, rates of photosynthesis correlated positively ($p = 0.1$) with relative abundance of omnivorous benthic macroinvertebrates; estimated rates during summer, after leafout and the concurrent decrease in incident solar radiation, did not. The significance of this finding is weakened, however, by the small size of the data set.

Usefulness of the median value of nitrate concentration for indicating stream impairment by nutrients is limited due to the requirement for intensive stream monitoring. Periphyton growth rate and stream photosynthesis during summer appear to be poor indicators of trophic status, due to poor correlation. The rate of stream photosynthesis during spring shows potential as an indicator of trophic status, at least in the represented ecoregions. Usefulness of this indicator is enhanced by the low level of monitoring required for evaluation at a site.