Summary of Agricultural Drainage and Pesticide Transport Model (ADAPT)

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The ADAPT model is a daily time-step, field scale, water table management model developed by extension and integration of GLEAMS (Knisel et al 1993), a root zone water quality simulation model, with DRAINMOD, a subsurface drainage model. The model simulates water and N uptake by crops and uses a water balance to account for surface runoff and water distribution in the soil profile. The model has been used, with some success, for watershed scale simulations (Gowda et al. 1999; Sogbedji and McIsaac 2006).

Denitrification is modeled as a first order decay in which the rate coefficient is a function of soil temperature, water content, and active organic carbon. The active organic carbon is the sum of fresh organic residue, organic carbon in animal waste, and organic carbon in potentially mineralizable nitrogen. Maximum denitrification rates are simulated when soil water is at saturation, and a soil water adjustment factor reduces the denitrification rate coefficient in a linear fashion to zero when soil water is 110% of field capacity. Additionally, a denitrification rate reduction factor is used to calibrate the model to observed data.

The model has been primarily applied to midwestern US croplands and agricultural watersheds, over periods ranging from a single growing season to 100 years, generally to address questions about impacts of management and climate on nitrate leaching to tile drains.

The denitrification model was based on laboratory incubations reported by Stanford et al. (1975a, b), in which previously air dried soils were mixed with water and KNO$_3$ solution and the disappearance of nitrate from solution was interpreted as denitrification. A relationship was identified between the apparent denitrification rate coefficient and two different measures of soil organic carbon: total organic carbon and glucose extracted in a CaCl$_2$ solution after 1 hr incubation at 100°C. The relationship with the extracted glucose explained 82% of the variation in rate coefficient, compared to 69% explained by total organic carbon.

The structure of the denitrification component of ADAPT is similar to many water quality models. There is little quantitative justification, however, for defining the organic carbon fraction relevant denitrification as the sum of fresh organic residue, organic carbon in animal waste, and organic carbon in potentially mineralizable nitrogen. Additionally, the final denitrification estimated by the model is adjusted by a calibration parameter to improve the overall fit between simulated and observed values of N fluxes.

In terms of model availability, we had obtained the model in 2000, including the FORTRAN source code, from developers at Ohio State University (Andy Ward), but Dr. Ward has not continued to work on model. There is a small group of developers and users, primarily associated with the U of Minnesota (David Mulla). Documentation was incomplete, and technical support from the model developers was inconsistent.

We were able to calibrate the model to represent approximately 80% of the monthly variation in observed nitrate flux in drainage waters from a 1500 km$^2$ watershed in Illinois, but ADAPT overestimated biological N fixation in soybeans by about a factor of two. Estimates of denitrification in agricultural fields were relatively low (~5 kg N ha$^{-1}$ yr$^{-1}$), but this was partly a
result of assuming that in-stream denitrification would also remove the equivalent of approximately 6 kg N ha\(^{-1}\) yr\(^{-1}\). We now believe a more reasonable estimate of in-stream denitrification would be 1 kg N ha\(^{-1}\) yr\(^{-1}\), and if the model had been calibrated with this value, it is likely that the estimated in-field denitrification would be closer to 10 kg N ha\(^{-1}\) yr\(^{-1}\). But the overestimation of N fixation in soybeans may also contribute to some overestimation of denitrification in the field.


