

# Modelling the hydrological behaviour and long-term nitrogen losses of artificially drained lowland catchments



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## Background and Objectives

- Artificial drainage is a common agricultural practice to improve soil moisture and aeration conditions, but it can lead to increased diffuse pollution of surface waters.
- Furthermore, preferential flow may result in an unexpected fast response of the tile drains.
- As tile drainage has rarely been explicitly included into distributed hydrological models, the model MHYDAS-DRAIN was developed to account for anthropogenic impacts and a fast flow component in small catchments.

## The Study Site

- Small, extensively tile-drained pleistocene catchment in North-Eastern Germany ( $\phi P = 664 \text{ mm}$ ,  $\phi \text{PET} = 561 \text{ mm}$ ) under arable land use with automatic sampling stations (Fig. 1) for hydrology and hydrochemistry.

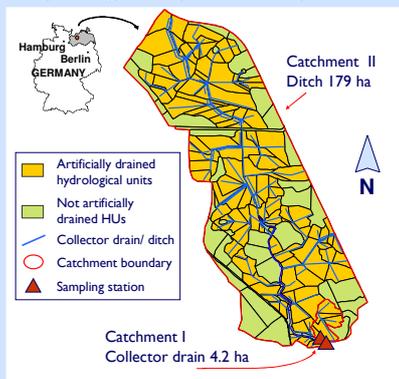


Figure 1: Delineation of the study catchment into hydrological units (HU).

- Analysis of daily to weekly composite samples for nitrate ( $\text{NO}_3^-$ ) using ion chromatography.

## The model MHYDAS-DRAIN

- Spatially distributed model (Tiemeyer et al., 2007) based on hydrological units derived from tile drainage and land use maps and connected to the drainage network.
- Tile drain discharge is assumed to be composed of preferential and matrix flow (Fig. 2), which are calculated with the Hooghoudt-equation and a transfer function approach.
- Estimates of discharge rates and  $\text{NO}_3\text{-N}$  losses for a range of meteorological conditions were derived using a regression approach and disaggregated long-term meteorological data.

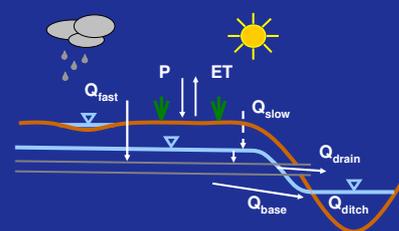


Figure 2: Conceptual model for MHYDAS-DRAIN

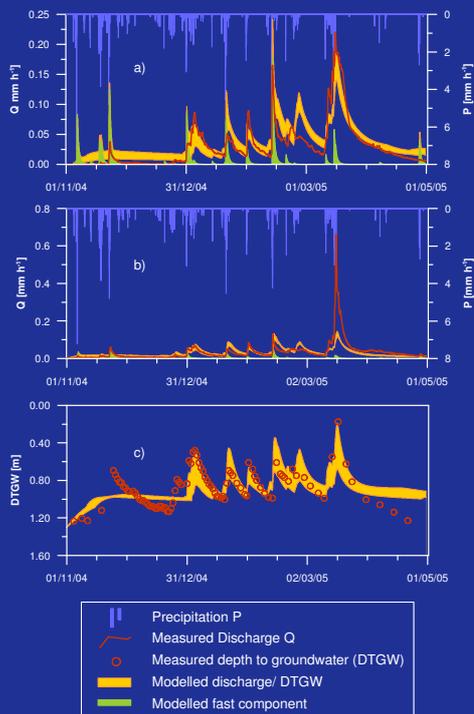


Figure 4: Precipitation, measured and modelled total and fast discharge  $Q$  and  $Q_{\text{fast}}$  a) at the collector drain outlet and b) in the ditch; c) measured and modelled depth to groundwater during the winter half-years of 2004/05 (calibration period).

## Results & Discussion I

- A global sensitivity analysis may be used to identify suitable calibration parameters for each model compartment (Fig. 3).
- Discharge rates and groundwater levels can be modelled well both during the calibration (Fig. 4) and validation period (not shown).
- However, snow melt events could not be captured satisfactorily.

### Regression $\text{NO}_3\text{-N}$ -Losses L:

$$L_{\text{drain}} = 0.146 Q_{\text{drain}} - 0.156 Q_{\text{drain, fast}} \quad R^2 = 0.85 \quad (\text{Eq. 1})$$

$$L_{\text{ditch}} = 0.175 Q_{\text{ditch}} - 3.374 Q_{\text{ditch, fast}} \quad R^2 = 0.86 \quad (\text{Eq. 2})$$

Thanks: Marianne Kietzmann, Tilo Hartwig and everyone else who helped with field & laboratory work.

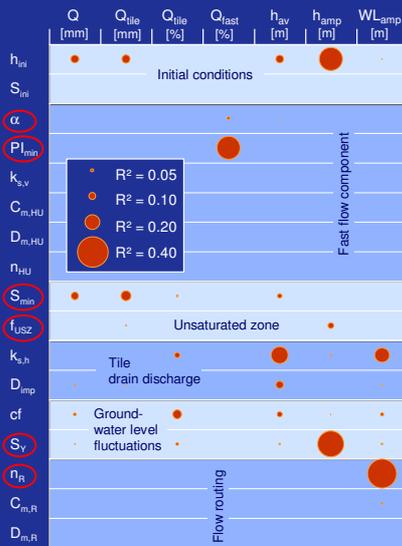


Figure 3: Results of the sensitivity analysis. The radii of the bubbles are proportional to the coefficients of determination  $R^2$ , and all shown correlations are significant at  $p < 0.05$ . Ordinate: model parameters; abscissa: model outputs.

## Conclusions & Outlook

- MHYDAS-DRAIN is a suitable model for catchments dominated by tile-drainage.
- However, to increase the reliability of the model estimates, wetter years and a suitable snow melt routine should be included.
- Overall, tile drained fields will have to be addressed with priority if a reduction of the diffuse nutrient pollution in lowland catchments is intended.
- Therefore, management approaches for tile-drained areas need to be developed.

## Results & Discussion II

- The fast flow component tends to reduce nitrate-nitrogen losses (Eq. 1-2).
- This regression model (Eq. 1-2) was significantly improved by taking into account modelled fast flow component in addition to the measured  $Q$ .
- Higher  $\text{NO}_3\text{-N}$  losses than measured so far have to be expected during wetter weather conditions in winter (Fig. 5).
- Artificially drained areas dominate the hydrology and the solute loss patterns.

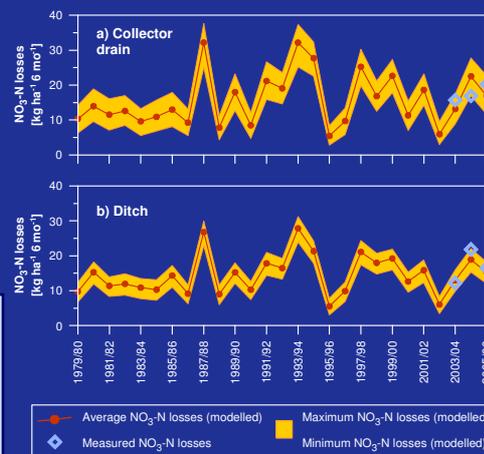


Figure 5: Modelled minimum, maximum and average nitrate-nitrogen losses during the winter half-years at the collector drain (a) and in the ditch (b). Measured nitrate-nitrogen losses for 2003/04 to 2005/06.

References: Tiemeyer B., Moussa R., Lennartz B. and Voltz M. 2007. MHYDAS-DRAIN: A spatially distributed model for small, artificially drained lowland catchments. Ecological Modelling 209: 2-20.