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Nutrient removal modelling: from a single filter to an entire catchment

Andreas Bauwe, Stefan Koch, Bernd Lennartz – University of Rostock





- Within NuReDrain filter systems for nutrient reduction (N, P) from agricultural waters will be develop.
- University of Rostock estimates the effect of filter systems at catchment scale for two watersheds.





Focus on Phosphorus in the German catchment

The Warnow river basin





P concentrations





- Good ecological status: 0.07 mg DRP/L and 0.1 mg TP/L (OGewV)
- Strong concentration decrease since the early 1990s
- Good ecological status regarding P is achieved for Warnow and most of its tributaries
- Is it perfect now?

Reduction Requirements for a clean sea North Sea Region NuReDrain



- The Warnow river basin must reduce 13 tons of Phosphorus annually.
- No decrease compared to the reference period so far.



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The model



P-Modeling using the Soil and Water Assessment Tool

- Constructing the model (weather data, land use, DEM, soils, streamflow and P data etc.)
- 2. Calibration and validation of streamflow
- 3. Calibration and validation of Ploads
- 4. Deriving scenarios
 - 8 gauging stations
 - Daily streamflow data
 - Monthly P-loads
 1992 2011



The model

 Interreg

 North Sea Region

 NuReDrain

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Vegetation: Leaf area index, Rooting depth, Base temperature etc. Management: Seeding and harvesting dates, crop rotation, fertilization etc.





- 1. Calibration (1992-2001) und validation (2002-2011) of stream flow for each subbasin on a daily basis.
- 2. Calibration and validation of P loadings for each subbasin on a monthly basis.
- 3. Implementation of scenarios (P reduction strategies)

Results – Hydrology







- Model performance streamflow
- At least satisfactory model performances
- Good or very good model performance for 4 out of 8 subbasins
- Only minor differences between calibration and validation
- Valid and robust model for streamflow

Results – Hydrology





- Discharge is dominated by groundwater and tile-drainage water depending on the subbasin.
- Surface runoff plays only a minor role.

 Large variation between subbasins

Results – Phosphorus







- SWAT-P performed considerably better than SWAT
- DRP dynamics were reproduced quite well for five subbasins
- Simulating DRP loadings failed for three subbasins

Results – Sources of P



0.14 **Observed** values WWTP Drainage water Surface runoff Groundwater 0.12 Annual DRP-loads (kg/ha) Obere Kösterbeck Zarnow Beke Brüeler Bach Warnow 0.10 Warnow 80.0 Mildenitz 0.06 Nebel 0.04 0.02 0.00 Modeled Observed Observed Modeled Modeled Observed Observed Modeled Dbserved Modeled Dbserved Modeled Observed Modeled Observed Modeled

- Good fit for measured and simulated values
- P transported via subsurface flow (groundwater, drainage water) dominates
- Contribution of point sources (WWTP) ca. 10%

P modelling – further reading



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Original Research Article

Predicting dissolved reactive phosphorus in tile-drained catchments using a modified SWAT model



Andreas Bauwe*, Kai-Uwe Eckhardt, Bernd Lennartz

Faculty of Agricultural and Environmental Sciences, Rostock University, Justus-von-Liebig-Weg 6, 18059 Rostock, Germany

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ABSTRACT

Phosphorus (P) is mainly leached by subsurface transport pathways in tile-drained landscapes. In this study, we modified the SWAT model (SWAT-P) by incorporating dissolved reactive phosphorus (DRP) losses from drainage water and the deep aquifer. SWAT-P was tested in a tile-drained lowland catchment using a multi-site calibration and validation approach. SWAT reached a good statistical performance regarding discharge for all sub-catchments and a daily time step. As discharge was dominated by subsurface flow, we optimized DRP concentrations for the drainage water (SWAT-P), the shallow aquifer (SWAT, SWAT-P), and the deep aquifer (SWAT-P) and left other P-related parameters at their default settings, since they did not influence the model output. DRP losses were simulated at a monthly time step using SWAT and SWAT-P. Nevertheless, SWAT-P performed considerably better than SWAT. Additionally, calibrated DRP concentrations

P filters



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Ghent University (BE)



Rostock University (DE)



Aarhus University (DK)

P filters



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P filter at a drainage outlet









P filters



Efficiency of the P Filter Box (P-concentrations)



- No effect for DRP, concentrations of inflow and outflow are nearly identical
- Clear effect for TP, concentrations at the outlet are lower compared to the inlet
- Efficiency of the Filter Box increases with rising TP-concentrations
- 27% of TP load could be retained



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Phosphordynamik

P-Austräge aus dränierten landwirtschaftlich genutzten Böden und Möglichkeiten zur Minderung

Petra Kahle, Andreas Bauwe und Bernd Lennartz (Rostock)

Zusammenfassung

Im vorliegenden Beitrag werden die Konzentrationen und Frachten an gelöstem reaktiven Phosphor und Gesamtphosphor im Dränwasser einer landwirtschaftlichen Nutzfläche sowie erste Erfahrungen beim Einsatz einer kontrollierten Dränung und einer Filterbox mit eisenhaltigem Sand als praktische Lösungsansätze zur Reduzierung der Phosphorausträge vorgestellt. Die Phosphorkonzentrationen und -frachten zeigten eine deutliche Abhängigkeit vom Niederschlags- und Abflussgeschehen bei ins-

Abstract

P loss from drained agricultural land and potential mitigation options

This article details the levels and loads of dissolved reactive phosphorous and total phosphorous in drainage water from a piece of agricultural land, together with the first lessons learned from the use of controlled drainage and a filter box using ferrous sand as practical solutions to reduce phosphorous loss.

P reduction scenarios





Evaluation of P filters in tile-drained fields at different spatial scales





- Good fit of measured and modeled values at different spatial scales.
- Effect of P filters on a catchment scale dependent on proportion of tiledrained areas.
- P filters could contribute to reduce
 P losses in the Warnow river basin.





- The P concentrations in the Warnow river basin have drastically decreased after the political change and remain at a low level for several years.
- Further reductions are required for a clean sea.
- With the help of an eco-hydrological model, streamflow and P-loads could be reproduced satisfactory.
- P is mainly transported via subsurface flow (groundwater, drainage water).
- Through the installation of P filters, the P loads can be further reduced.
- However, enormous efforts will be required to achieve environmental targets.

Thank you very much for your attention