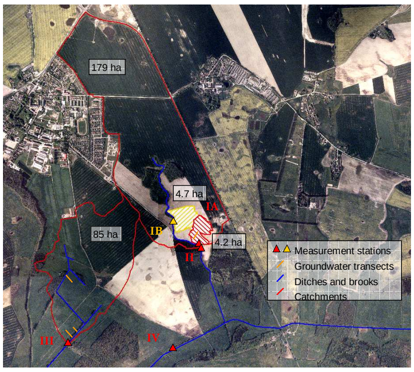
Brook Zarnow gauging station

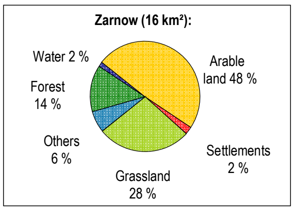
Zarnow basin, Germany

Basin characteristics

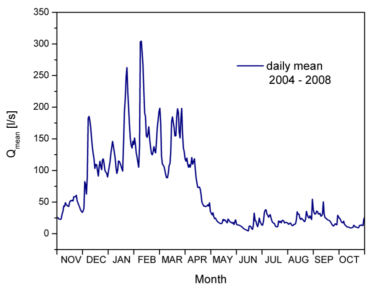
River Basin / River Basin (according EU-WFD)	Warnow-Peene basin (Mecklenburg-Vorpommern)
Operation (from… to…)	2001, still in operation
Gauge coordinates / Gauge datum:	54°01'N; 12°13'E / 34.5 m a.s.l.
Catchment area:	15.5 km^2
Elevation range:	34.5 - 50.6 m a.s.l.
Basin type: (alpine, mountainous, lowland)	lowland
Climatic parameters: (mean precipitation, temperature and others)	665 mm mean precipitation, 8.2°C mean temperature, 490 mm mean crop reference evapotranspiration (1979-2008)
Land use:	Mainly agricultural (arable land, grassland), forest
Soils:	Luvisols, Gleysols, Histosols, Cambisols
Geology:	Quaternary (ground moraine, Weichsel ice-age)
Hydrogeology: (Type of aquifers, hydraulic conductivity)	Quaternary deposits (Mergel) Unconfined aquifer
Characteristic water discharges: (Q_{min}, Q_{max}, Q_{mean})	Q_{min} = 0.0 l s^{-1}, Q_{max} = 1094 l s^{-1}, Q_{mean} = 64 l s^{-1}

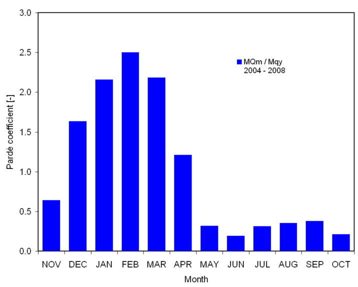
Map of the research basin



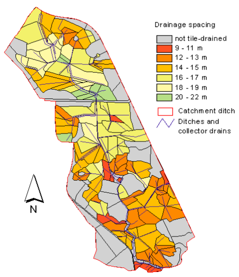


Mean hydrograph / Pardé flow regime





Special basin characteristics (hydrogeology, lakes, reservoirs etc.)



Drainage spacing and hydrological units for modelling with MHYDAS-DRAIN

Background and choice of the research catchment:

- To improve soil moisture and aeration conditions, agricultural land in lowland areas is frequently artificially drained.
- Tile drainage shortens the residence time of water in the soil and may therefore accelerate and increase the losses of nutrients and contaminants to surface water bodies.
- Especially the ubiquitous drainage of peatlands caused the loss of valuable ecosystems and environmental damage.
- Most of the tile drainage studies have concentrated on the plot scale.
- The Zarnow catchment is a typical artificially drained lowland catchment with tile drainage of arable land on mineral soils and ditch drainage of grassland on organic soils.

Instrumentation and data

Measured hydrological parameters	Measuring period	Temporal resolution	Number of stations
Ditch and brook discharge	2001 - 2003 2003 - cont.	Daily 15 minutes	2 1
Tile drain discharge	2003 - cont.	Hourly	3
Precipitation	2001 - 2003 2003 - cont.	Daily Impulse/ 0.1 mm	1
Air temperature, humidity, wind speed	2001 - 2003 2003 - cont.	Daily 15 minutes	1
Groundwater level	2003 - 2005 2005 - 2008	Daily to weekly	17 33
Surface water: Cl^-, NO_3^-, SO_4^{2-}, Na^+, K^+, Ca^{2+}, Mg^{2+}	2001 - 2003 2003 - cont.	Daily to weekly	2 4
Surface water: P_t and PO_4-P	2003 - 2006	Daily - biweekly	4
Groundwater: Cl^-, NO_3^-, SO_4^{2-}, Na^+, NH_4^+, K^+, Ca^{2+}, Mg^{2+}, P_t	2005 - 2008 (winter only)	Daily - weekly	18
Groundwater: TOC, Fe_t, Al_t, Mn_t, colour	2007/08 (winter only)	Daily - weekly	6
Stable isotopes of nitrate: $\delta^{15}N$ and $\delta^{18}O$	2003/04 (winter only)	Event-based	2

Applied models

1. MHYDAS-DRAIN
2. SWAT (in preparation)

Main scientific results

- Artificially drained areas dominate the hydrological dynamics and the hydrochemistry of lowland catchments and must thus be prioritarily addressed when combating diffuse pollution.
- Discharge generation is dominated by tile drainage and groundwater flow, while overland flow only occurs when snowmelt, heavy rainfall and frozen soils concur. The main discharge period is the winter. Tile drainage amounts to 27 % of the total rainfall on an annual basis, and to 54 % in winter.
- Nitrate-nitrogen concentrations are very high, especially in the artificially drained subcatchments: 32 % of all samples exceeded the drinking water limit of 11.3 mg l^{-1} NO_3-N, and 79 % of all samples exceeded the limits of water quality class (2.5 mg l^{-1} NO_3-N, "good quality" according to the WFD).
- During nearly all discharge events, the highest NO_3-N concentrations went along with the peak discharge rate, even in the end of the winter.
- The annual NO_3-N losses of up to 55 kg ha^{-1} are strongly depending on the annual rainfall ($0{,}7034 < R^2 < 0{,}8876$), while the fertiliser application shows no effect (yet) on the studied time-scale.
- Applying a mixing model for subcatchments IA, II and IV (in which the grassland is probably less degraded than in SC III) shows that ca. 25 % of the total catchment area is responsible for 75 % of the NO_3-N losses.
- With the exception of the peatland, phosphorus concentrations and losses are, in contrast, generally low.
- Solute concentrations in the groundwater of the subcatchment dominated by artificially drained peatlands showed a high temporal and spatial variability. Concentrations and losses of most solutes where highest in this subcatchment, and due to ongoing drainage and degradation, improvement is not in sight.
- The model MHYDAS-DRAIN can be used for modelling small catchments dominated by artificial drainage. However, snowmelt events aroused problems with model calibration and validation.
- Calibration parameters for MHYDAS-DRAIN could be identified with a multi-target sensitivity analysis. The spatial and temporal resolution of the modelling domain and the calibration criteria determine the calibration results.
- Therefore, they need to be urgently considered when addressing the reduction of diffuse pollution.

Key references for the basin

1. Tiemeyer, B., Kahle, P. & B. Lennartz, 2009. Phosphorus losses from an artificially drained rural lowland catchment in North-Eastern Germany. Agricultural Water Management 96(4): 677-690.
2. Tiemeyer, B., Moussa, R., Lennartz, B. & M. Voltz, 2007. MHYDAS-DRAIN: A spatially distributed model for small, artificially drained lowland catchments. Ecological Modelling 209: 2-20.
3. Tiemeyer, B., Frings, J., Kahle, P., Köhne, S. & B. Lennartz, 2007. A comprehensive study of nutrient losses, soil properties and groundwater concentrations in a degraded peatland used as an intensive meadow – implications for re-wetting. Journal of Hydrology 345: 80-101.
4. Deutsch, B., Voss, M. & P. Kahle, 2006. Assessing the source of nitrate pollution in water using stable N and O isotopes. Agronomy for Sustainable Development 26: 263-267.
5. Tiemeyer, B., Kahle, P. & B. Lennartz, 2006. Nutrient losses from artificially drained catchments in North-Eastern Germany at different scales. Agricultural Water Management 85: 47-57.
6. Kahle, P. & B. Lennartz, 2005: Untersuchungen zum Stoffaustrag aus landwirtschaftlich genutzten Dränflächen in Nordostdeutschland. Wasserwirtschaft 95: Nr. 9, 23-27

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