Department of Hydrology and Water Resources Management

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Identification of herbicide transport pathways in drainage ponds

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BACKGROUND

- crucial need to reduce non-point source agricultural inputs to achieve the aims of the European Water Framework Directive
- semi-natural drainage ponds become increasingly important as removal measures for plant protection products in agricultural productive areas
- behaviour of pesticide loads within drainage ponds is neither well monitored nor understood yet
- drainage ponds can reach retention efficiencies that are comparable to larger wetland areas → demand of modifications to prolong hydraulic residence times and to let natural transfer and transformation processes take effect

AIM

- to monitor drainage ponds in daily resolution and to gain an improved understanding of reduction of herbicide load peaks from drainage flows before reaching receiving river systems

METHODS

- consideration of different discharge routes of herbicide loads entering the drainage ponds
- focus on 2 herbicide parent compounds (PC) commonly used in rapeseed (*Metazachlor*) and winter crops (*Pendimethalin*) and 2 transformation products (TP), which differ in characteristics

Tab.1: Characteristics of PCs and TPS – OA (oxalic acid), – ESA (sulfonic acid) in soil, water and sediment (PPDB, 2017)

herbicides	crops	mobility in water	adsorption in soil	DT50 soil	DT50 water	DT50 sediment
PC Pendimethalin	winter wheat					
PC Metazachlor	rapeseed					
TP Metazachlor - ESA						
TP Metazachlor – OA						

no weak moderate high — short moderate long

- area of interest in Northern Germany is characterized by sandy-loamy soils and agricultural land use
- investigation area drains via connected ponds in the river system
- to capture the hydrological behaviour and daily herbicide loads in drainage pipes, a daily monitoring from 10/2016 to 01/2017 after autumn application is carried out

Field *(8.5 ha)*

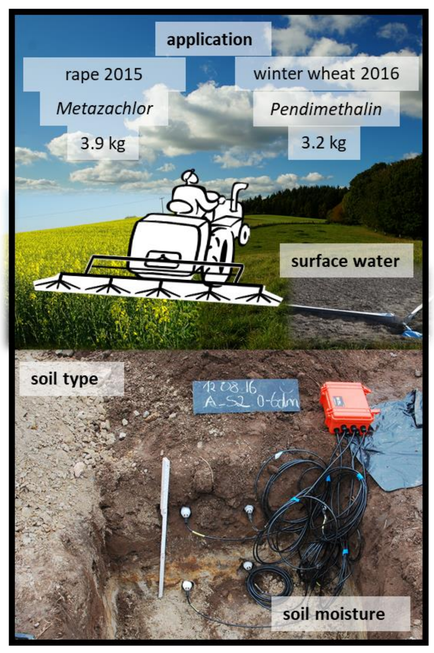
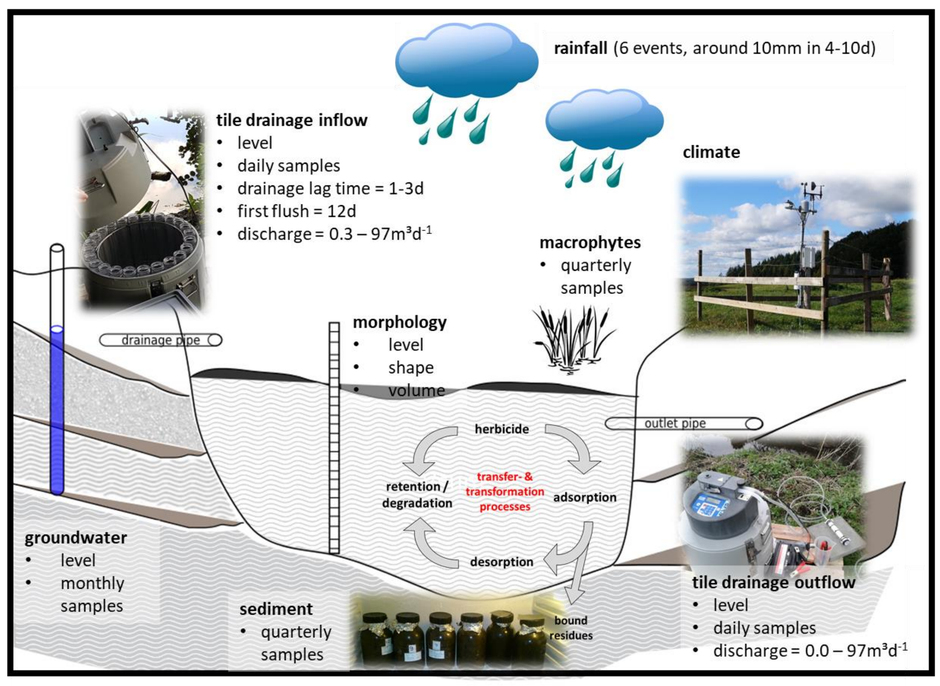


Fig.1: Monitoring design of 10 week field campaign in autumn 2016: soil type analysis and soil moisture measurements on field-site (left) and collection of macrophyte, sediment and water samples for pesticide analysis from drainage pond (right) complemented by hydrological measurements

Drainage pond *(Ø 0.8m water level, Ø 332m² surface area, 143m³ volume, round-shaped)*



RESULTS

Hydrology

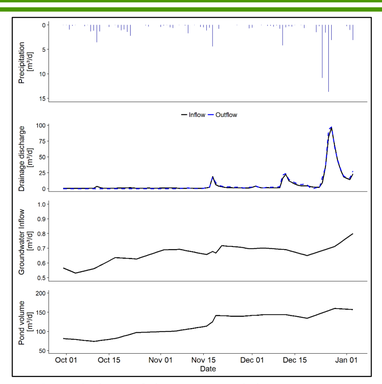


Fig.2: Hydrology of drainage pond during monitoring period October 2016 to January 2017

Drainage pipe

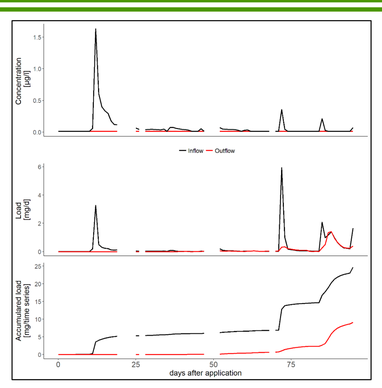


*Fig.3: Concentration and load of the winter crop herbicide **Pendimethalin** applied in autumn 2016 (kfoc= 8942-27578 [ml/g], DT50 water = 4, DT50 soil = 39.8-187, DT50 sediment = 16 days) at inlet (black) and outlet (red) of drainage pond during monitoring period 2016*

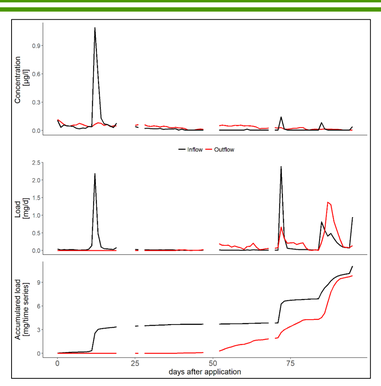


*Fig.4: Concentration and load of the rapeseed herbicide **Metazachlor** applied in autumn 2015 (kfoc= 72.5-83.5 [ml/g], DT50 water = 216, DT50 soil = 3-21, DT50 sediment = 21 days) at inlet (black) and outlet (red) of drainage pond during monitoring period 2016*

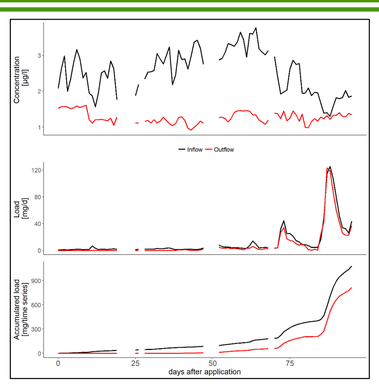


*Fig.5: Concentration and load of the rapeseed transformation product of Metazachlor: **Metazachlor – OA** (kfoc= 25 [ml/g], DT50 soil = 53-137) at inlet (black) and outlet (red) of drainage pond during monitoring period 2016*

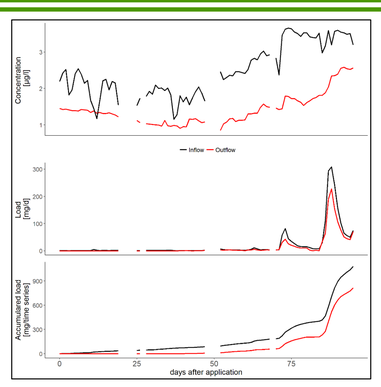


*Fig.6: Concentration and load of the rapeseed transformation product of Metazachlor: **Metazachlor – ESA** (kfoc= 5 [ml/g], DT50 soil = 60-171) at inlet (black) and outlet (red) of drainage pond during monitoring period 2016*

Ground-water

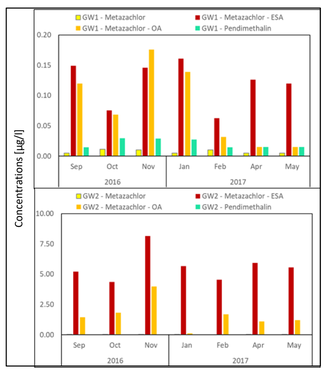
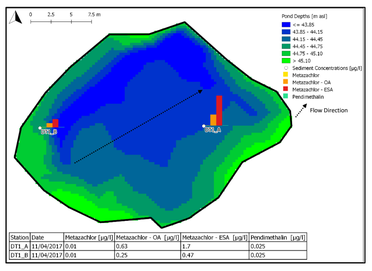


*Fig.7: Herbicide concentrations in **groundwater** (3m depth). Gauge GW1 shows concentrations close to pond and GW2 at field site.*

Sediment



Station	Date	Metazachlor [µg/l]	Metazachlor - OA [µg/l]	Metazachlor - ESA [µg/l]	Pendimethalin [µg/l]
DT1_A	11/04/2017	0.01	0.63	1.7	0.025
DT1_B	11/04/2017	0.01	0.25	0.47	0.025

*Fig.8: **Sediment** concentrations (1:10 water eluate: LOQ Pendimethalin=0.025 and Metazachlor=0.01 µg/l; solid sediment LOQ=0.05 mg/kg) within drainage pond. Two samples were taken from a flat zone, near to shore (DT1_B) and from a deeper zone in flow direction (DT1_A) in April 2017. The PCs Pendimethalin and Metazachlor and the TPs of Metazachlor were determined.*

* LOQ = Limit of quantification

Other samples

herbicide concentrations in macrophytes and solid sediments < LOQ; no surface runoff samples in 2016 due to low rainfall amount

Retention summary

*Tab.2: Herbicide and TP **retention** amounts reaching the drainage pond (RAC = regulatory acceptable concentrations (UBA,2017))*

herbicide	share of application amount received at tile drainage inflow during monitoring		retention of load within drainage pond during monitoring		compliance of threshold value at tile drainage outflow	
	%	mg	%	mg	compliance	RAC [µg/l]
Pendimethalin (2016, 3.18kg)	0.0008	25	63	16	yes	0.63
Metazachlor (2015, 3.91kg)	0.0003	11	12	1	yes	0.88
Metazachlor – OA	0.06	1084	25	270		
Metazachlor – ESA	0.05	1984	34	675		

FINDINGS

- **pond surface water:** detection of highest loads for TPs *Metazachlor – OA* und *– ESA (Fig.5, Fig.6)*; first flush delivered high concentrations of PCs *Pendimethalin* and *Metazachlor* at pond inlet (Fig.3, Fig.4), even though *Metazachlor* application was in year 2015
- **groundwater:** GW1 (close to pond) showed low concentrations of all target compounds, because of effluent groundwater condition (Fig.2.); in GW2, only *Metazachlor* – TPs were detected in considerably higher concentrations (Fig.7)
- **sediment:** only concentrations of TPs *Metazachlor – ESA* and *– OA* detected, in flow direction higher (Fig.8)
- **retention efficiency:** ∅ retention 34% in drainage pond (12 to 34 % for mobile and up to 63% for non mobile compounds) → correlation of retention efficiency and kfoc for PCs; mobile *Metazachlor* – TPs showed good retention though low kfoc, but found in resoluble part of sediment samples (Fig.8)

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