Können Schwammstädte giftige Schadstoffeinleitungen reduzieren?

Masterarbeit– FS 2023

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Forschungsfrage

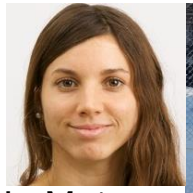
Können Schwammstädte giftige Schadstoffeinleitungen reduzieren?

1. Wie hoch sind **Mikroschadstoffkonzentrationen** im urbanen Abfluss?

2. Welche **Auswirkungen** hat das heutige graue System?

3. Verringert blau-grüne Infrastruktur die Belastung?

Untersuchungsgebiet

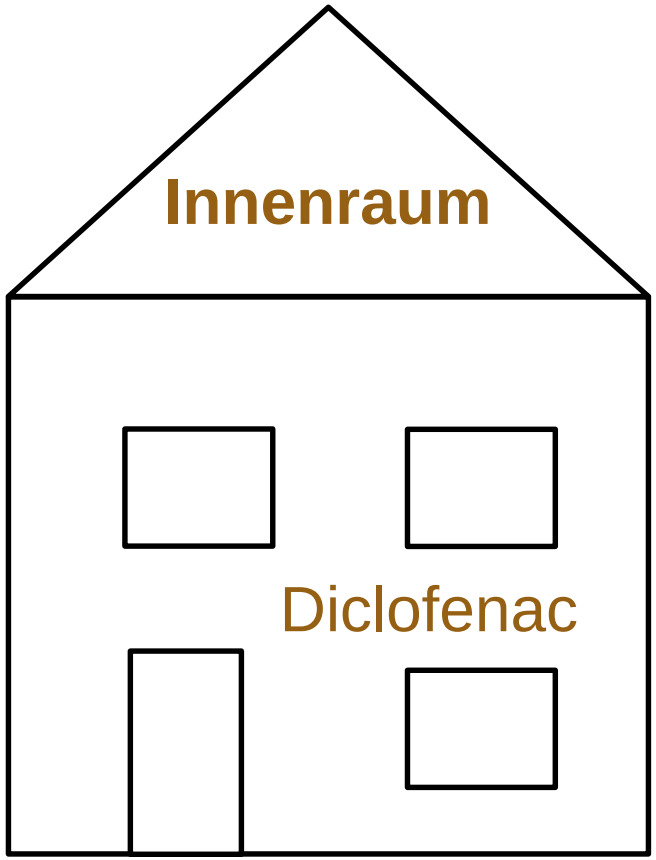


L. Mutzner
2016-2017

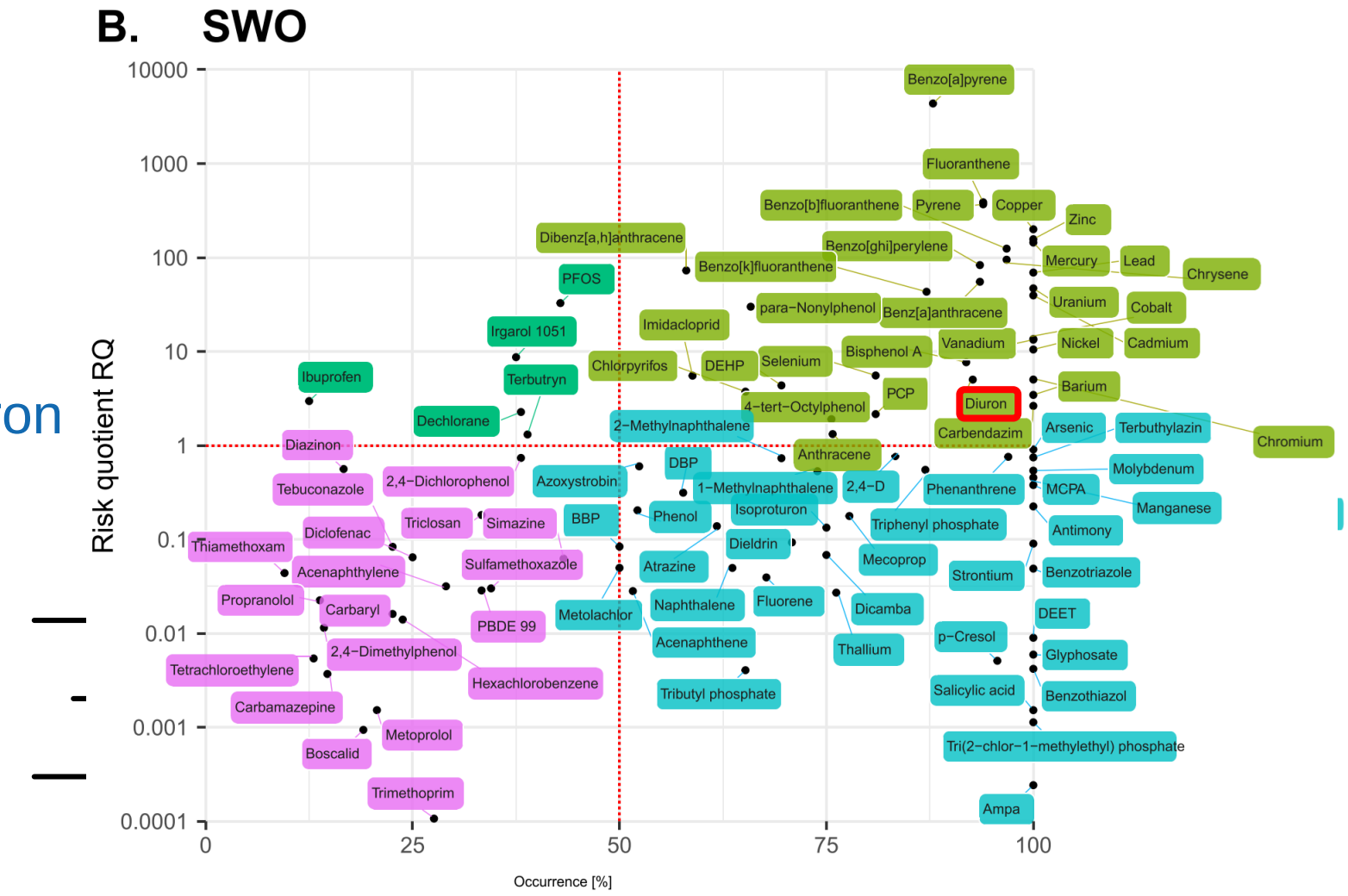
L. Mutzner
2016-2017

V. Furrer
2021-2022

Mikroverunreinigungen

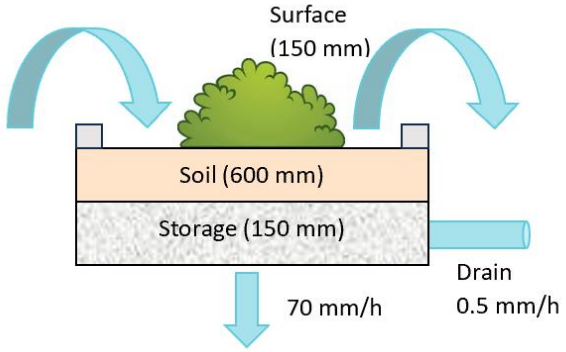


Diuron



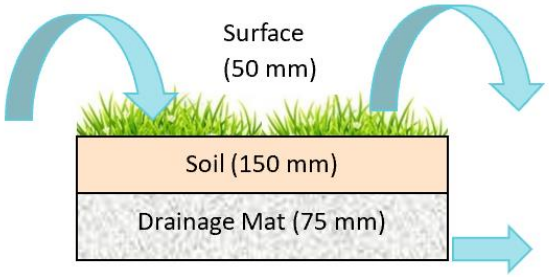
Blau-Grüne Infrastructuren (BGI)

Biorückhaltezelle (BC)



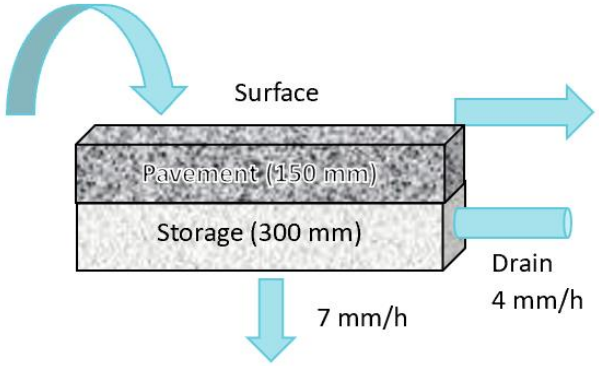
Durchlässige Flächen: Gärten, Grünflächen, Verkehrsinseln

Gründach (GR)



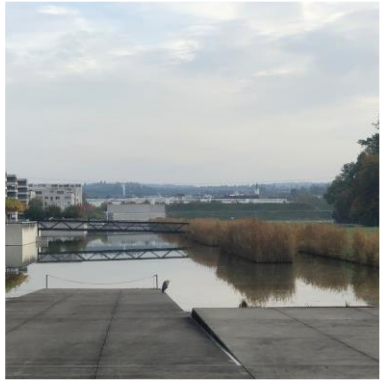
Flachdächer

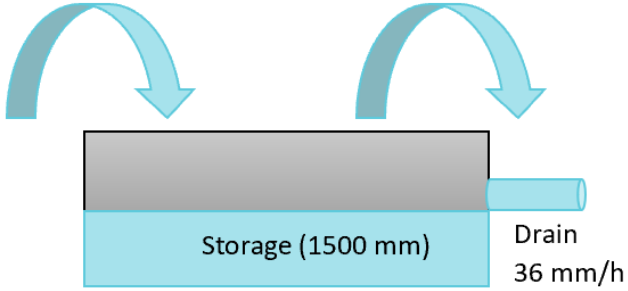
Durchlässiger Belag (PP)



Undurchlässige Flächen: Parkplätze, landwirtschaftliche Wege

Urbane Feuchtgebiete (UW)

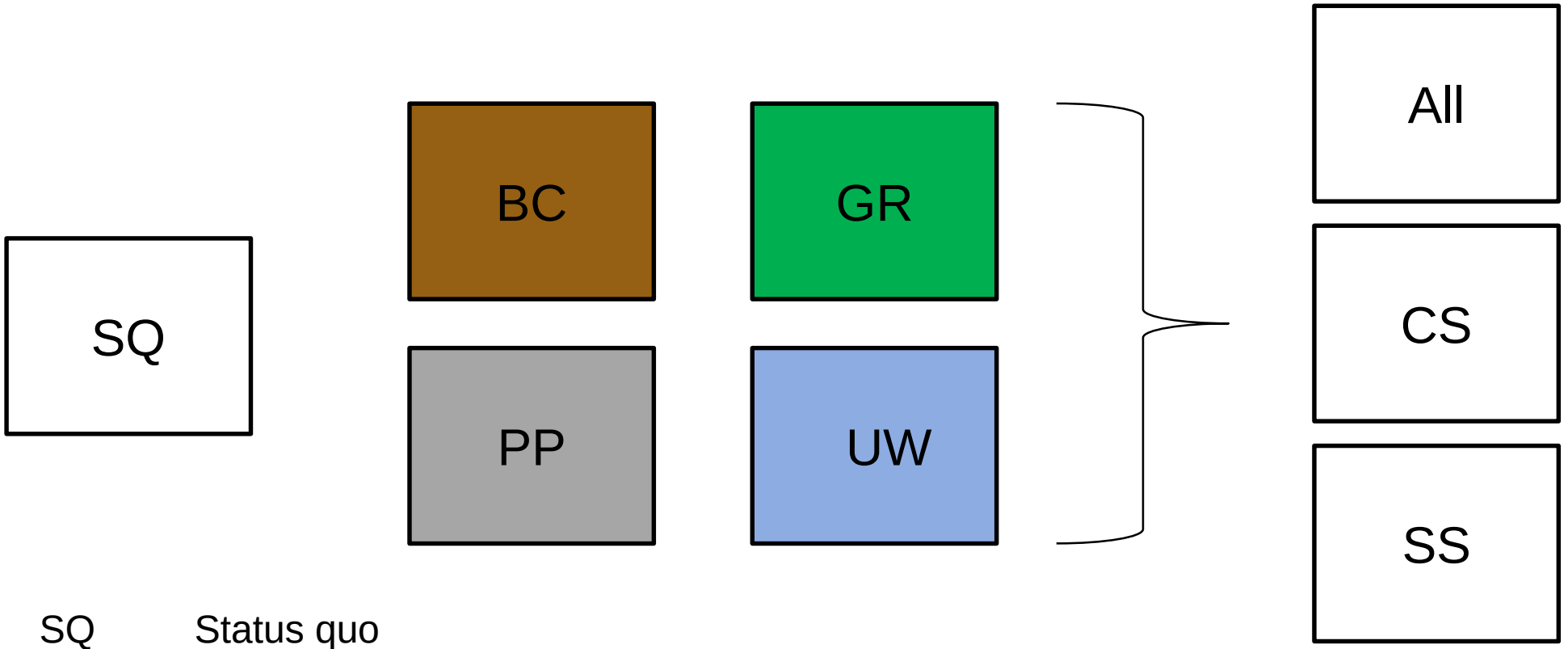




Durchlässige Flächen: Gärten, Grünflächen, Verkehrsinseln

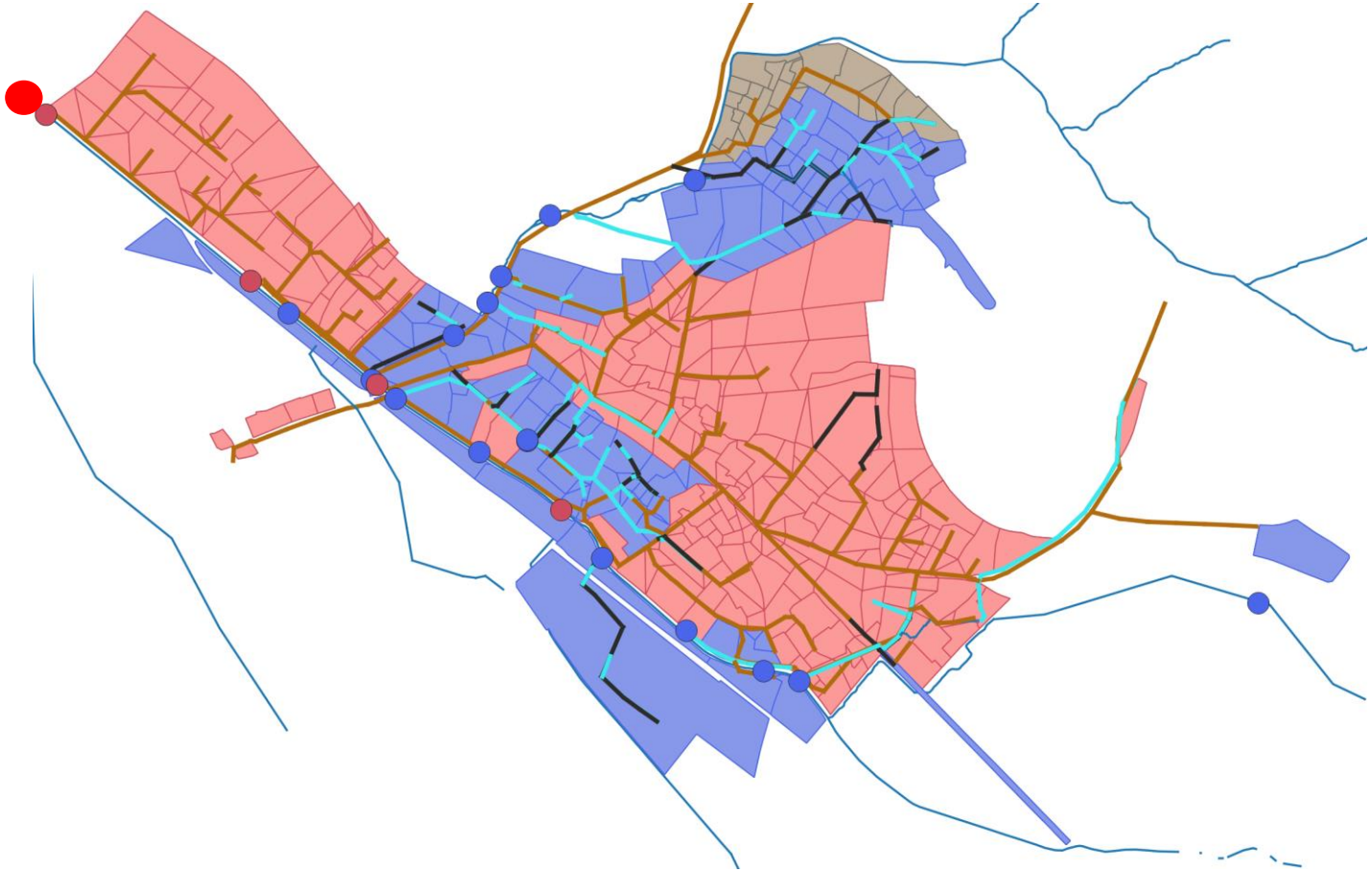
Alle Fotos aufgenommen durch G.B. Cavadini

Szenarien



SQ	Status quo	All	All subcatchments
BC	Bioretention cell	CS	Combined system
GR	Green roof	SS	Separate system
PP	Pervious pavement		
UW	Urban wetlands		

Ökologische Risikobewertung



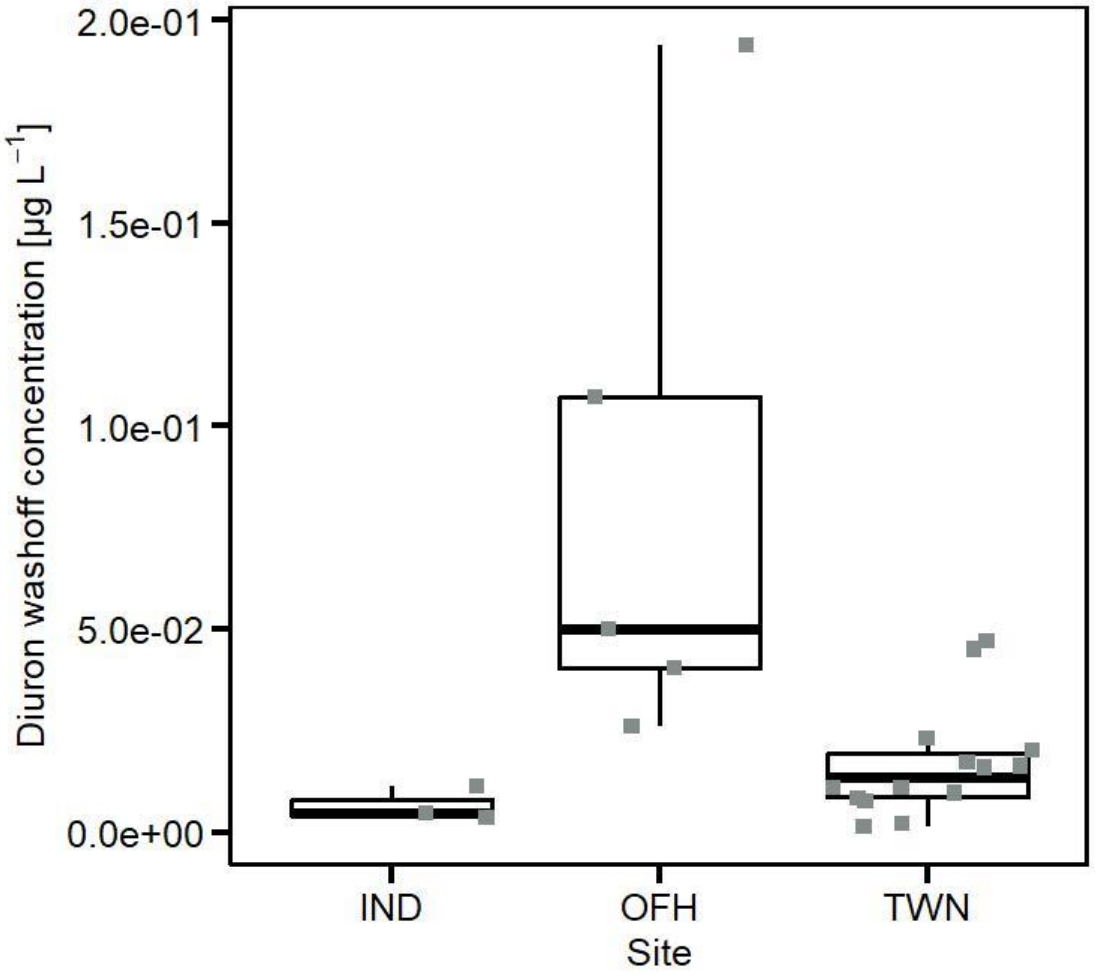
$$C_{Fluss} = \frac{\sum M_{Auslauf}}{Q_{Fluss}}$$

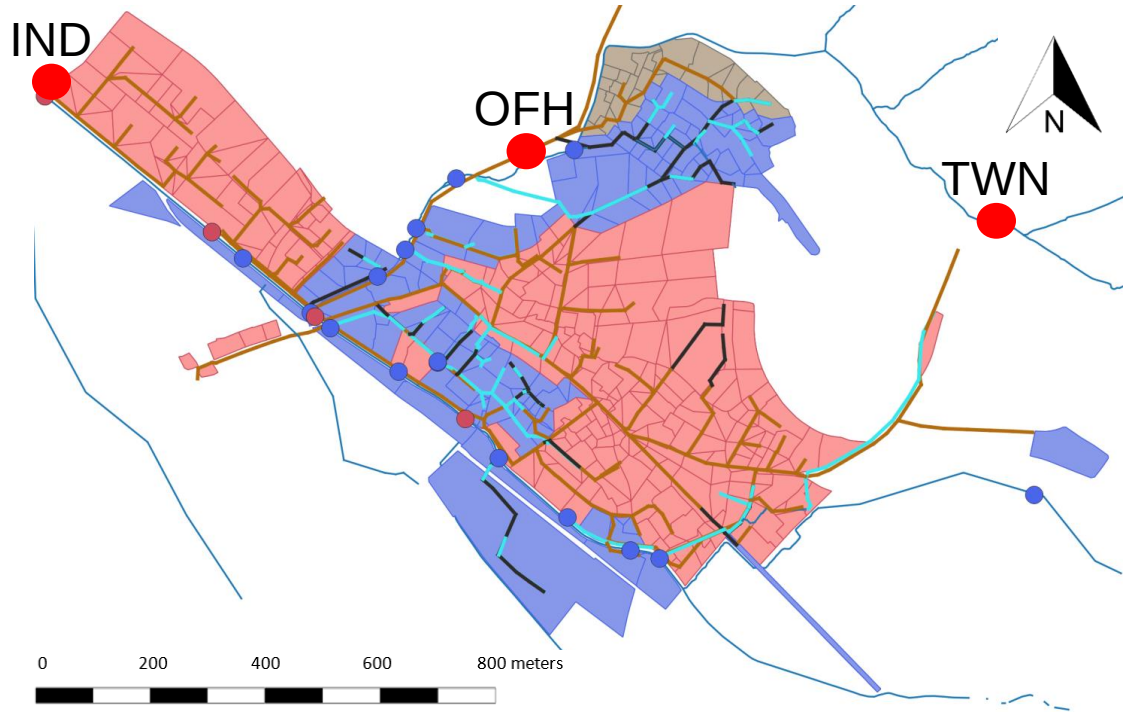
$$aRQ = \frac{C_{Fluss}}{Grenzwert}$$

Grenzwert:
1. EQS
2. PNEC
3. LC50/1000

aRQ	acute risk quotient
EQS	environmental quality standard
PNEC	Predicted no effect concentration
LC50	lethal concentration where 50% of the organisms are killed

Konzentrationen von Mikroverunreinigungen





Entlastete Mikroschadstoffbelastung

SQ: Status Quo	All: All Catchments	CS: Combined System	SS: Separate System
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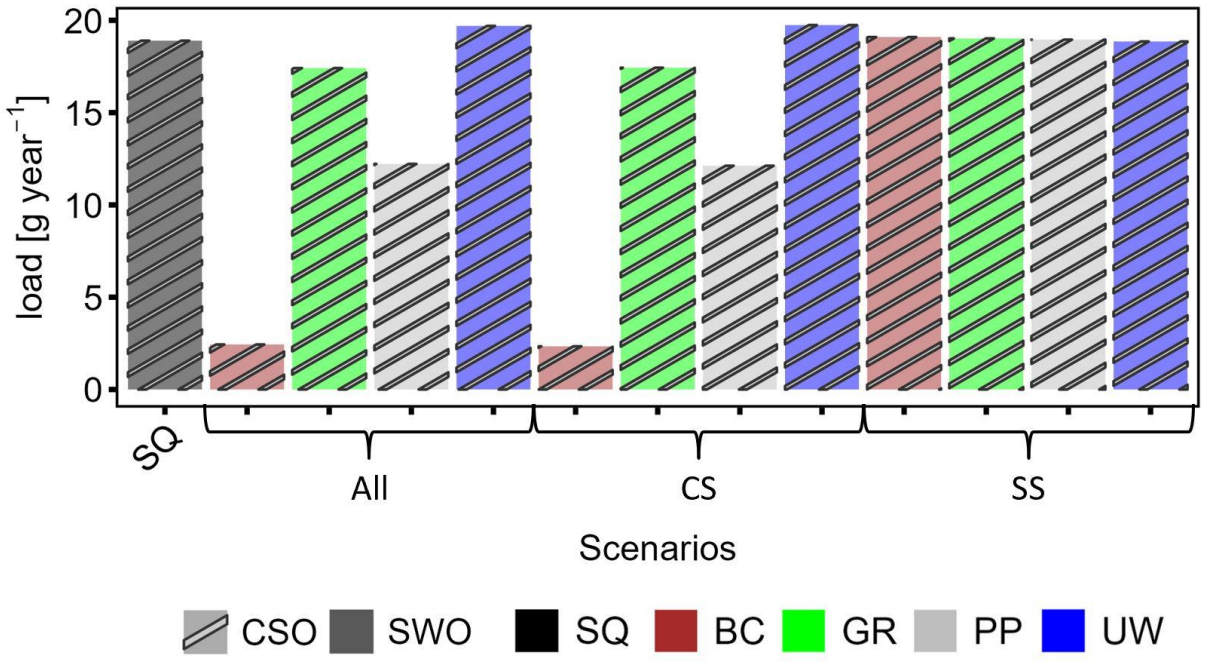
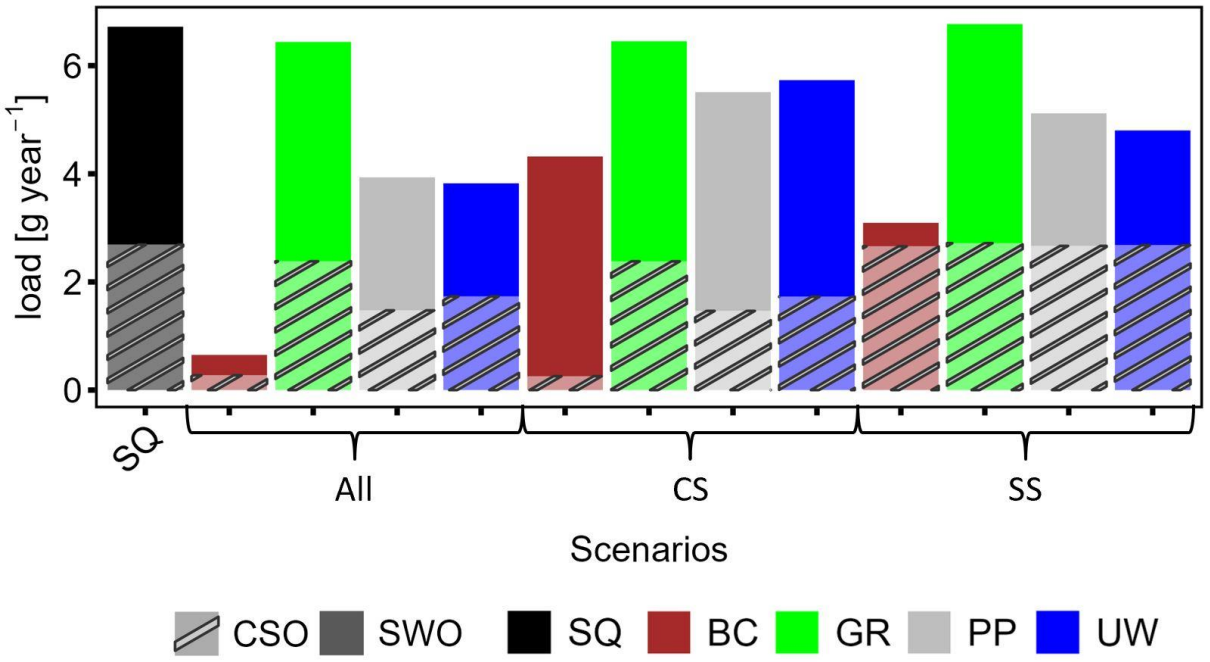
Arzneimittel: Diclofenac



Strassenabfluss: 6PPD-quinone



Risikoquotient

SQ: Status Quo	All: All Catchments	CS: Combined System	SS: Separate System
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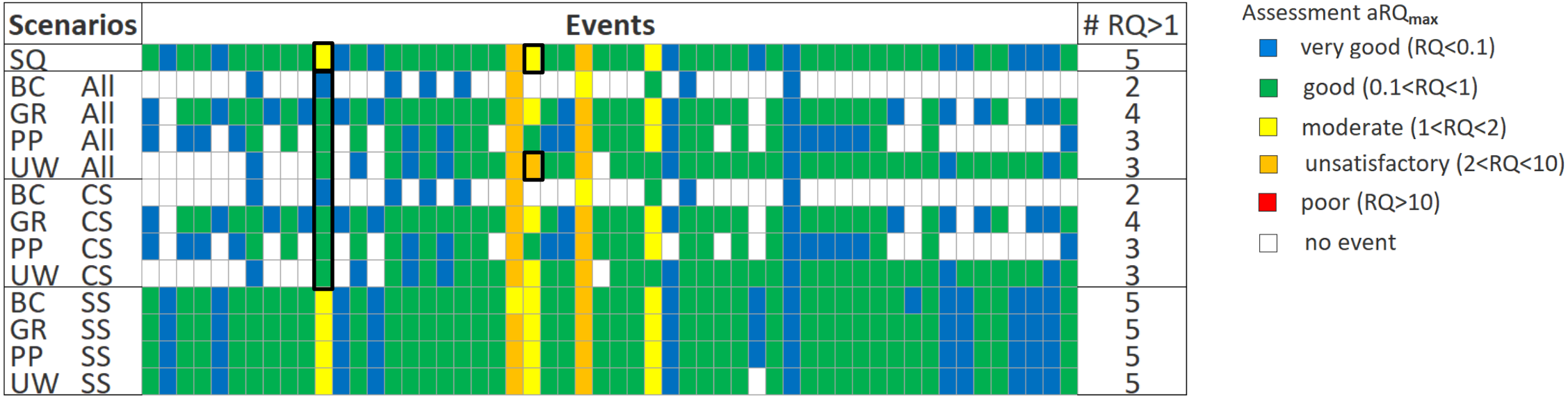
Arzneimittel: Diclofenac



Risikoquotient

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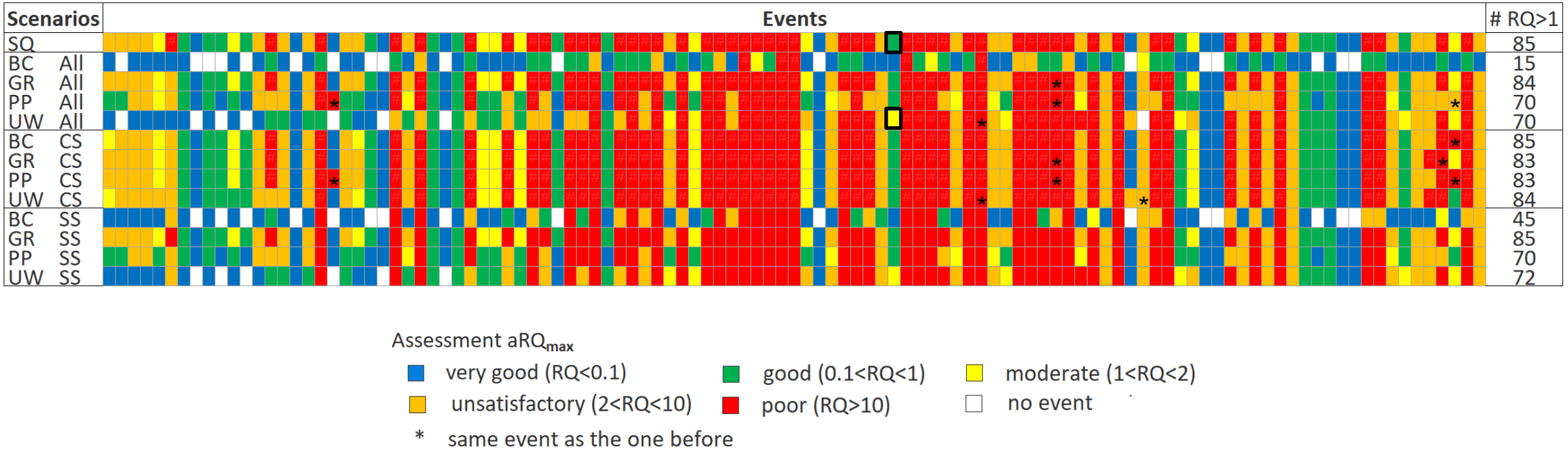
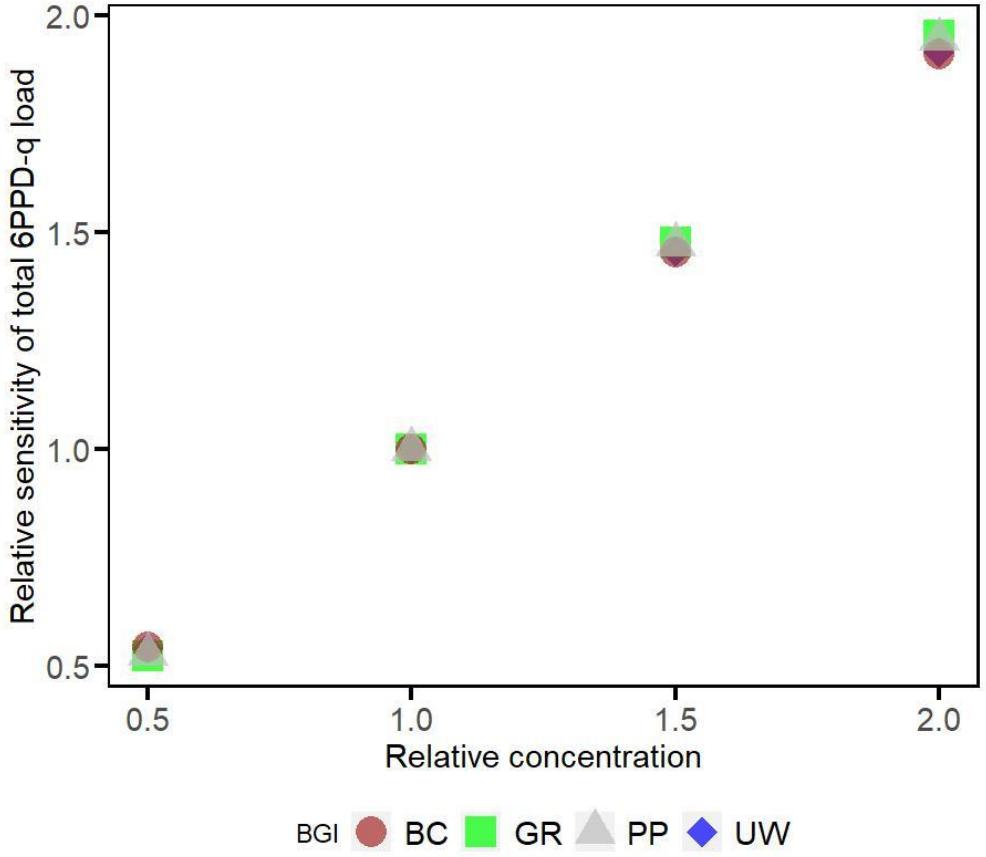
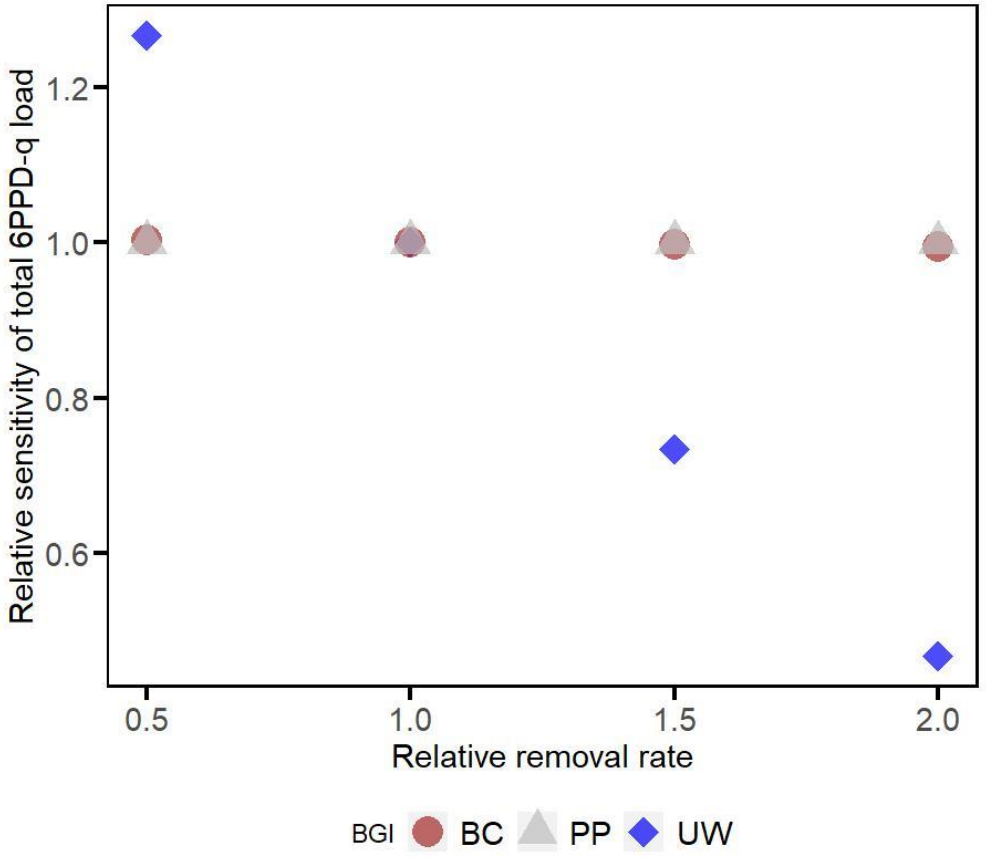


Sensitivitätsanalyse





- Konzentration linear sensitiv
- Entfernungsrate hat kaum Auswirkungen auf BGI mit Infiltration

Schlussfolgerung

- **Quelle** der Mikroverunreinigung relevant → BGI auf verschiedenen Flächen angewendet
- Verringerung der Belastung bedeutet nicht gleich geringeres Risiko
- Hohes Risiko für 6PPD-quinone und Diclofenac → **Massnahmen erforderlich**
- **BC beste BGI** gefolgt von PP
- Entfernungsrate sensitiv für BGI, welche nicht infiltrieren
- Konzentration ist wichtig → **Kontrolle** an der **Quelle** oder **zirkuläre Wassernutzung**

Ausblick

Entferungsrate

↓

Konzentrationen im Grundwasser

↓

Gesundheitsrisiko für Menschen

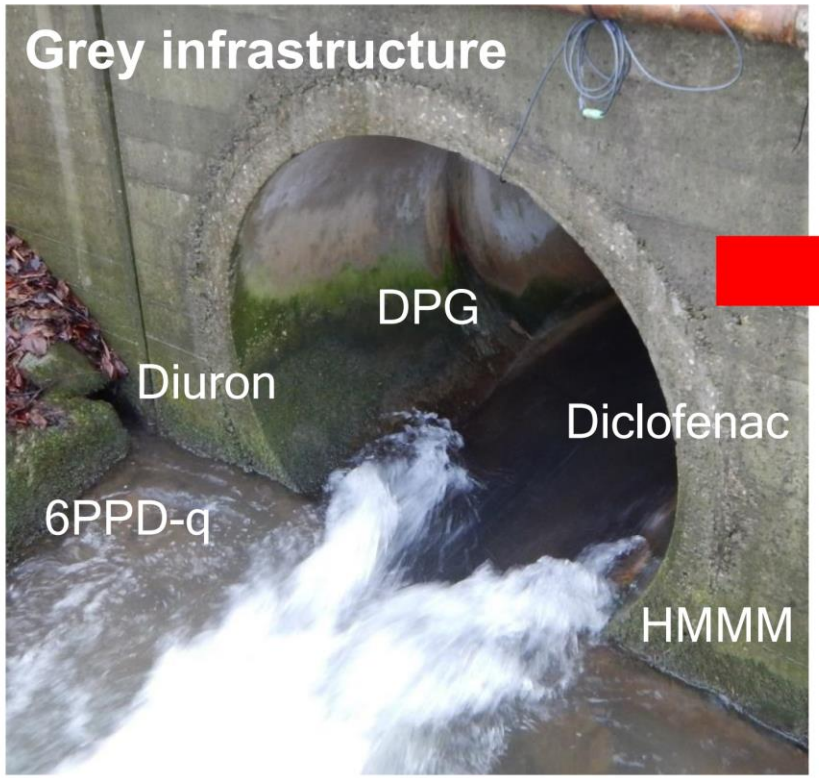
→ Trinkwasser

→ Nicht-trinkbare Zwecke

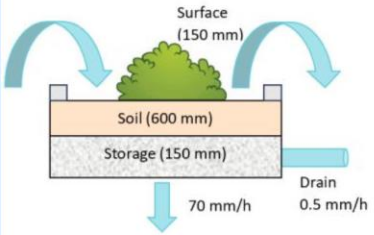
Können Schwammstädte giftige Schadstoffeinleitungen reduzieren?

Ja

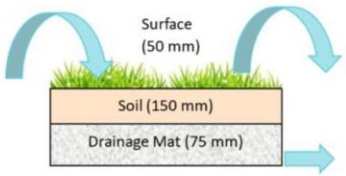
Blue-green infrastructures (BGI) can reduce contaminants in sewer overflows



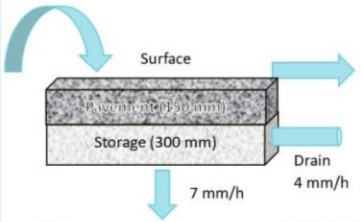
Urban catchment SWMM simulation



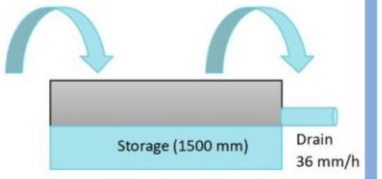
Bioretention cell (BC)



Green roof (GR)



Porous pavement (PP)



Urban wetland (UW)

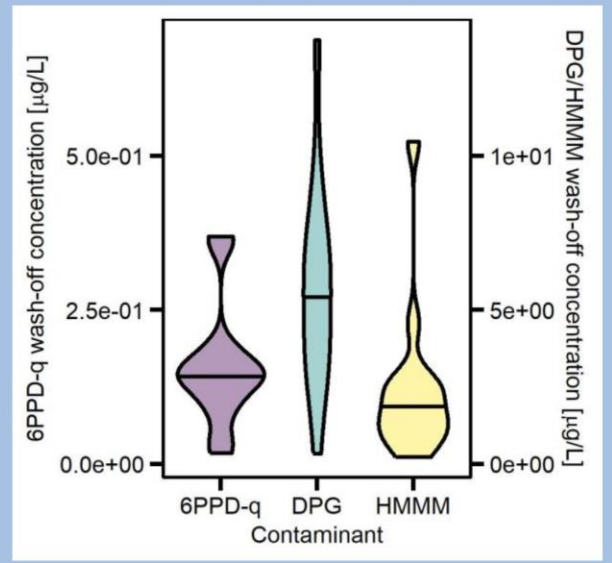
? Wash-off concentration

Total discharged load

Eco-toxicological risk

Contaminants assessment

Tire rubber leachate runoff calculation:



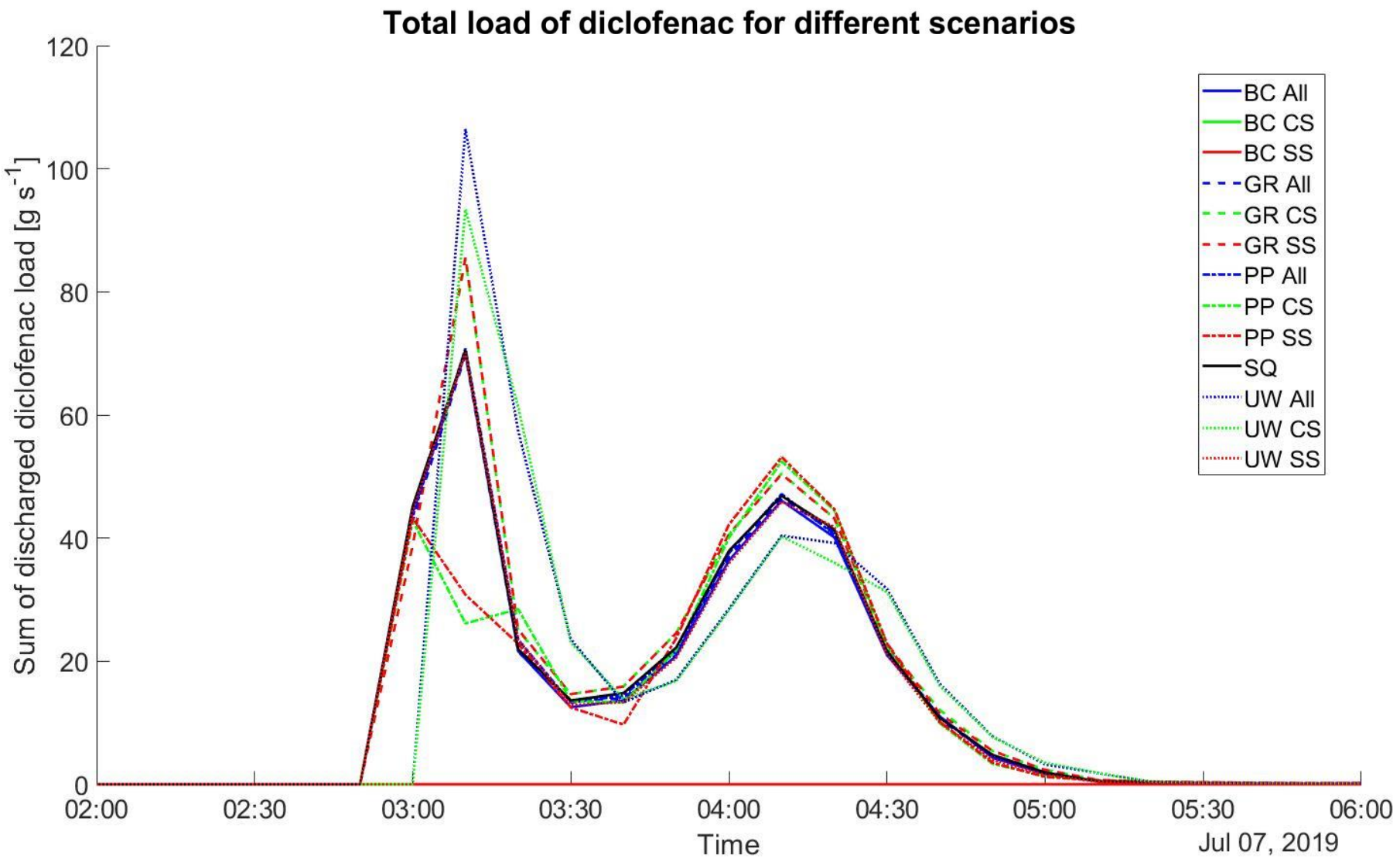
BC most effective for all studied contaminants

BGI can reduce the hours of exceeded risk in surface water by up to 90%

Quellen

L. Mutzner, V. Furrer, H. Castebrunet, U. Dittmer, S. Fuchs, W. Gernjak, M.-C. Gromaire, A. Matzinger, P. S. Mikkelsen, W. R. Selbig, et al. A decade of monitoring micropollutants in urban wet-weather flows: What did we learn? Water Research, 223:118968, 202

Anhang


Total load of diclofenac for different scenarios
Sum of discharged diclofenac load [g s-1]
120
100
80
60
40
20
0
02:00
02:30
03:00
03:30
04:00
04:30
05:00
05:30
06:00
Time
Jul 07, 2019
BC All
BC CS
BC SS
GR All
GR CS
GR SS
PP All
PP CS
PP SS
SQ
UW All
UW CS
UW SS

Risk Quotient

SQ: Status Quo	All: All Catchments	CS: Combined System	SS: Separate System
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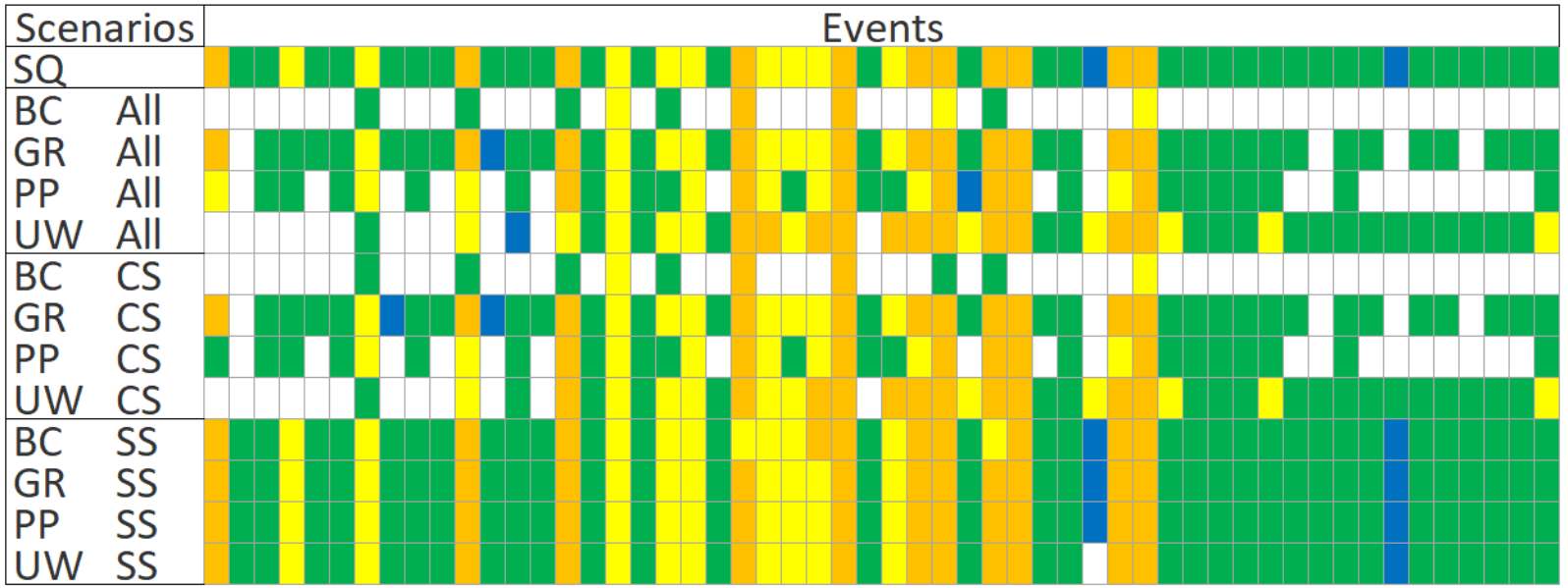
Pharmaceutical: Diclofenac



Assessment aRQ_{max}

- very good (RQ<0.1)
- good (0.1<RQ<1)
- moderate (1<RQ<2)
- unsatisfactory (2<RQ<10)
- poor (RQ>10)
- no event
- * same event as the one before

Removal Rates

	BC	PP	UW	
6PPD-q	50	40	40	Standford University (2020)
DPG	50	40	40	
HMMM	50	40	40	
Diuron	20	10	40	Standford University (2020), Page et al. (2010), Page et al. (2011), Mauffrey et al. (2017)

Fairbairn et al. (2018)

First results of BGI scenarios

SQ: Status Quo	All: All Catchments	CS: Combined System	SS: Separate System
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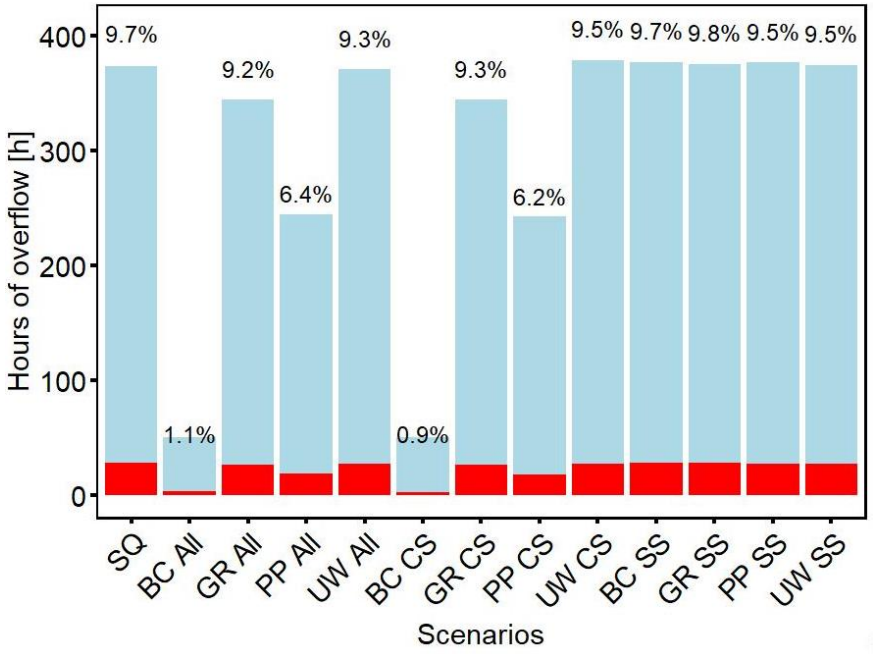
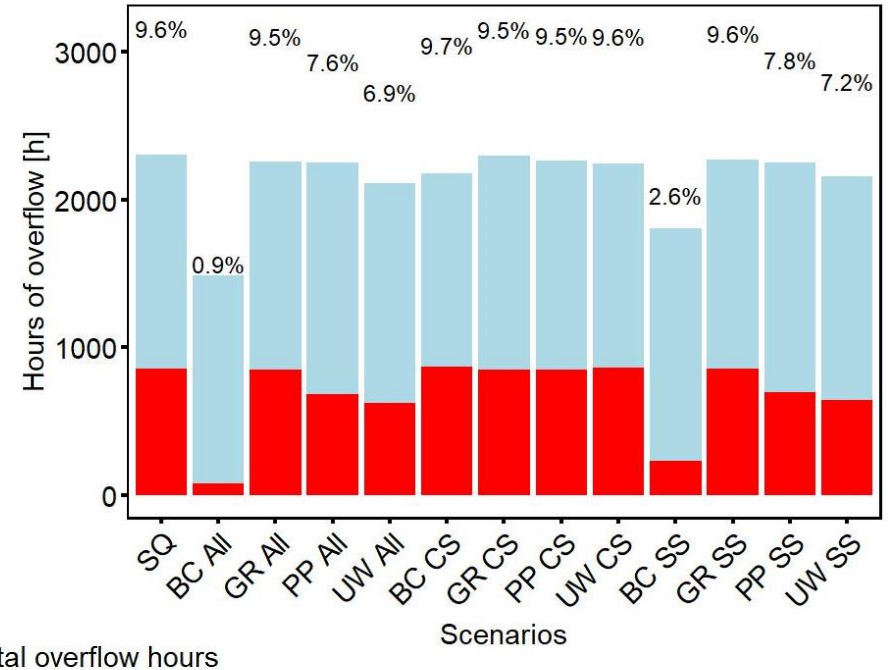
Pharmaceutical: Diclofenac

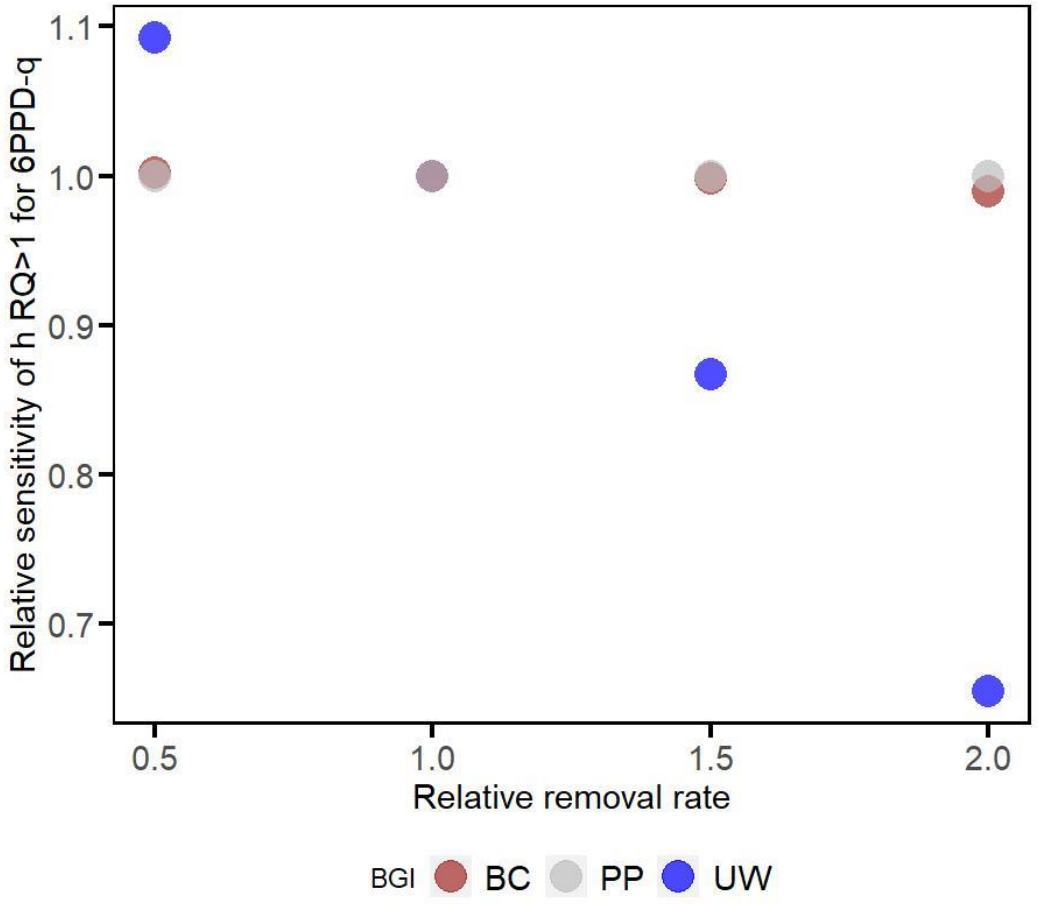


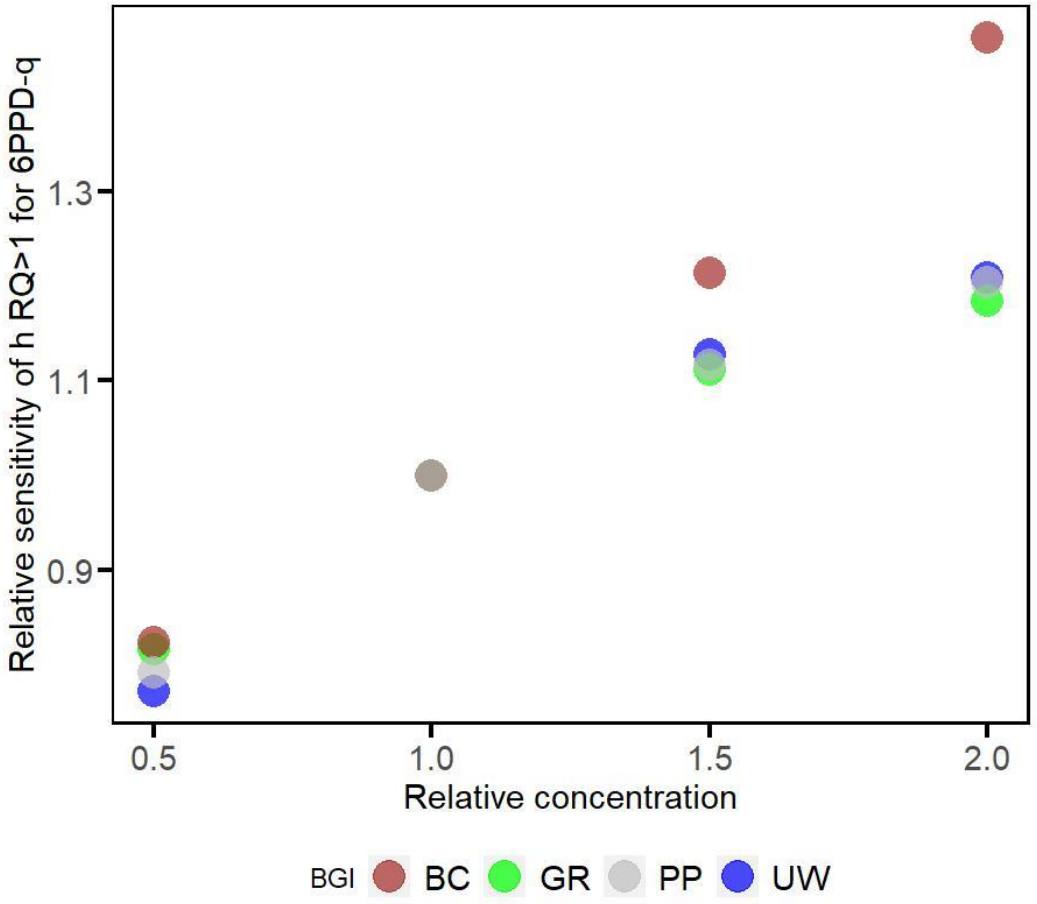
Road runoff: 6PPD-quinone



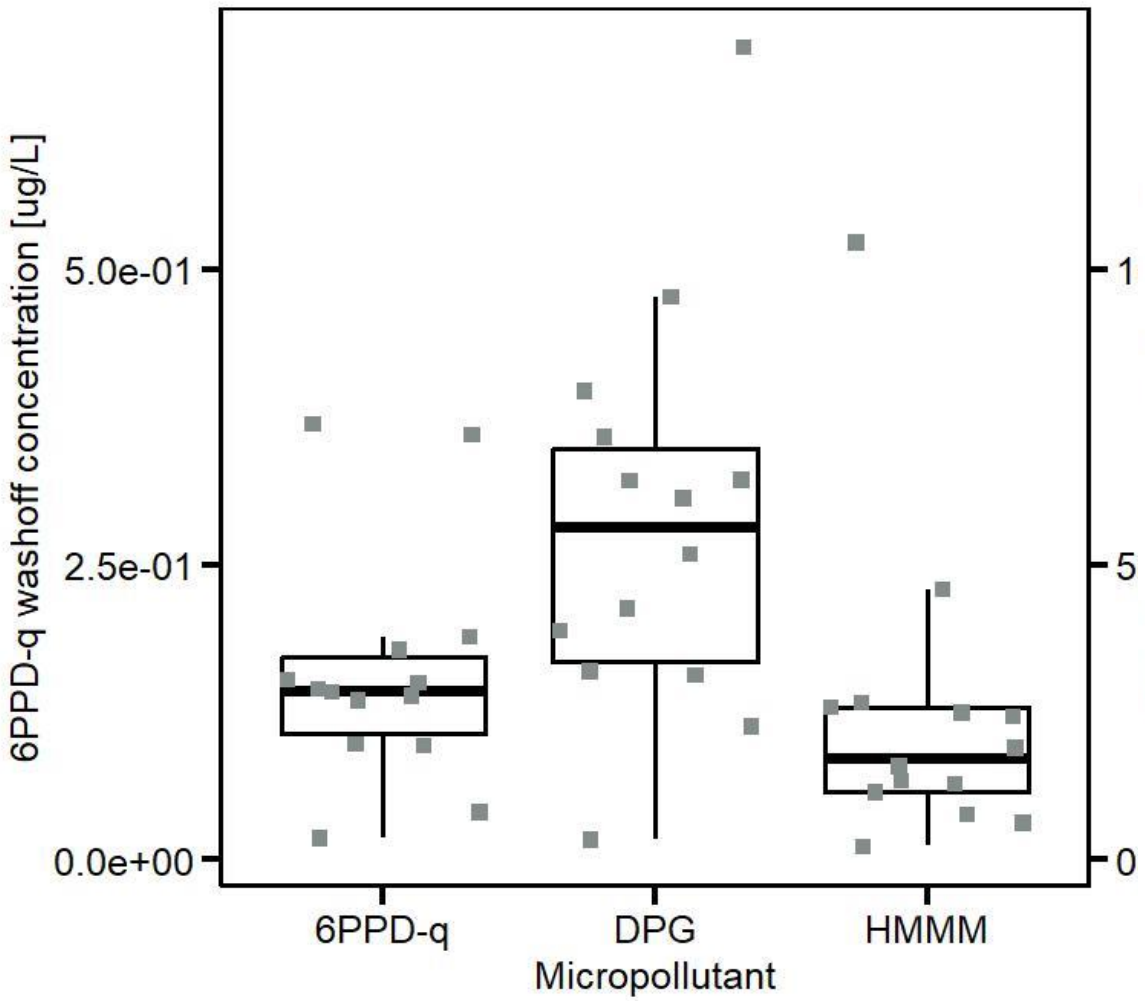
Hours RQ>1 | Total overflow hours

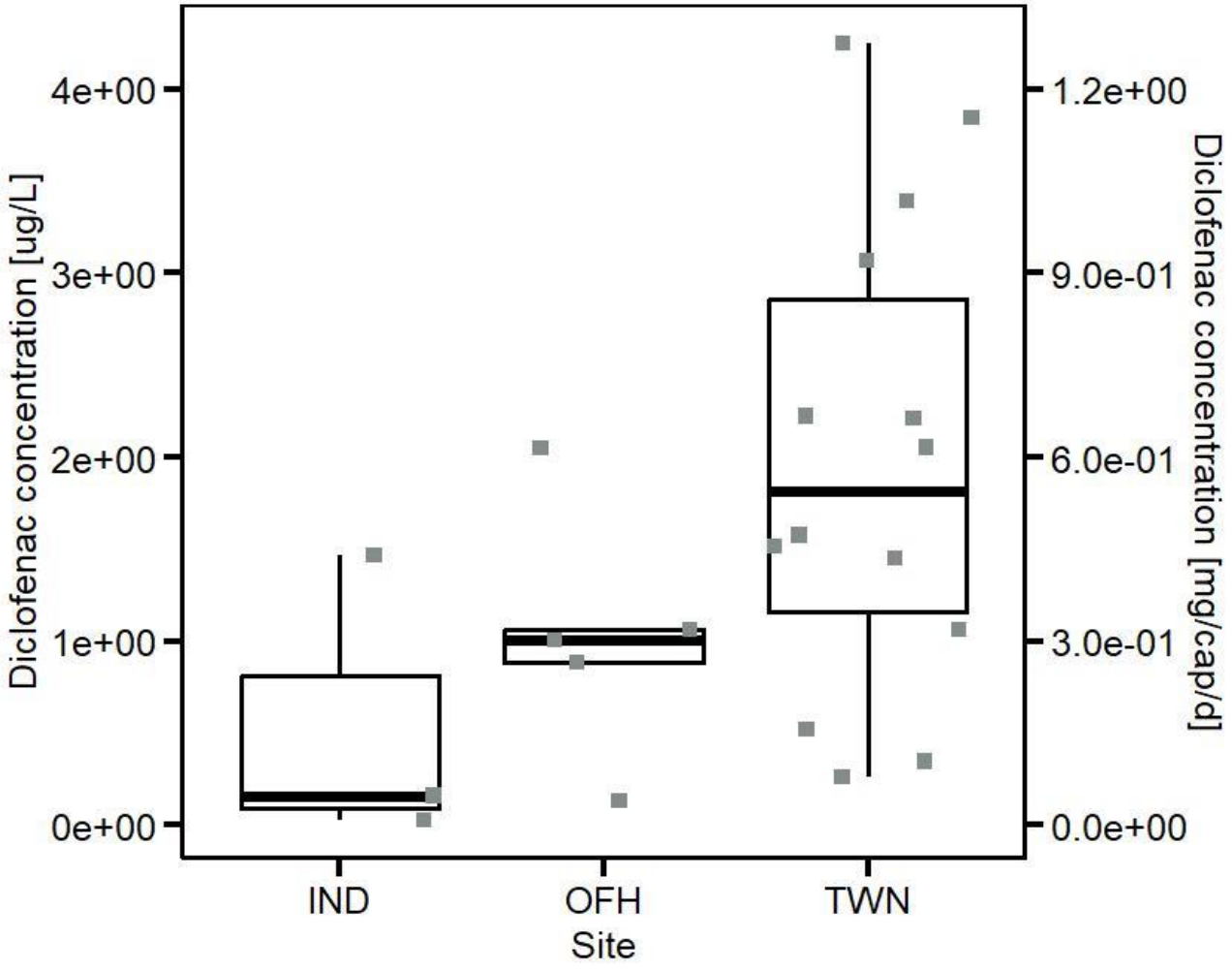
Sensitivity Analysis



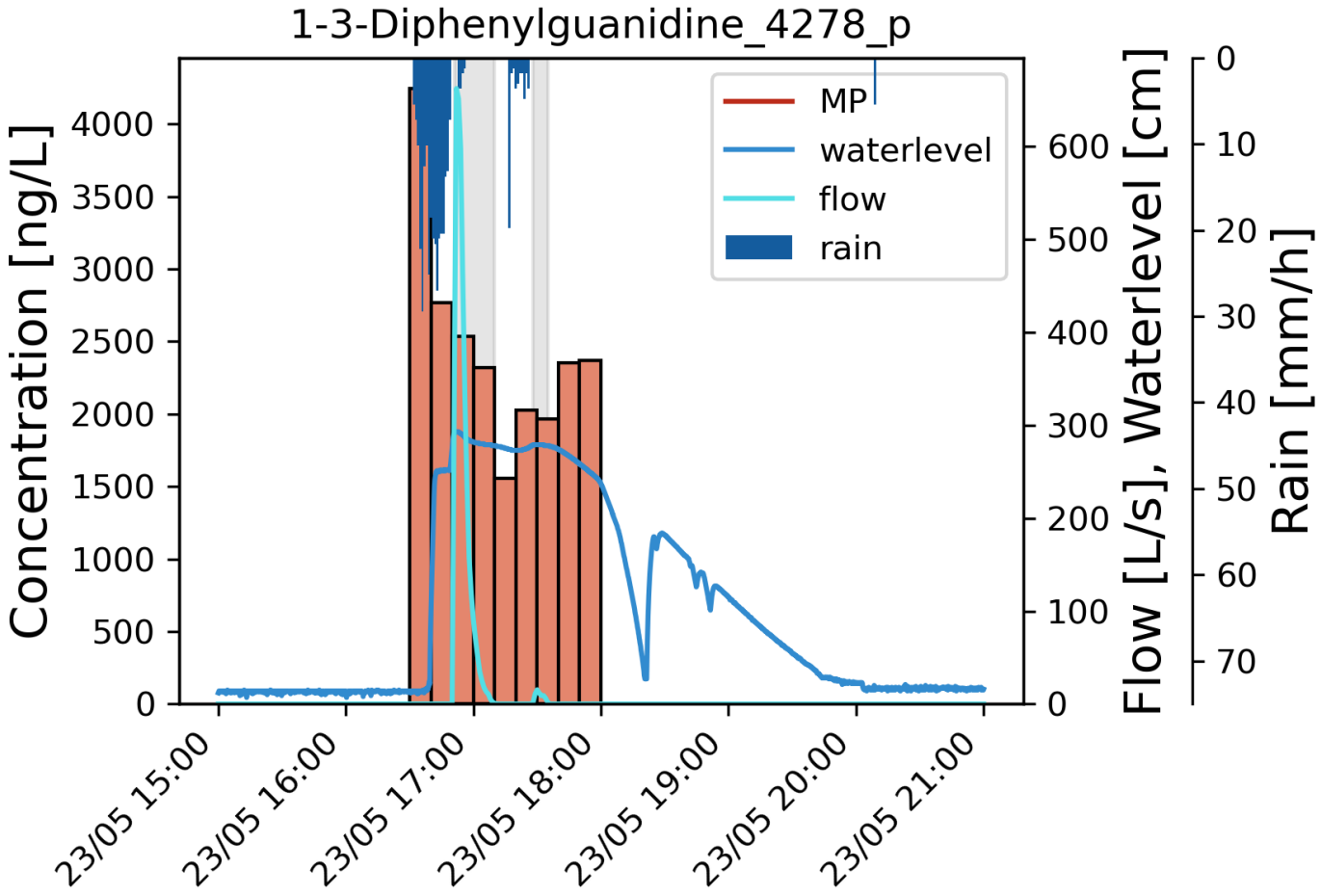


Concentrations of Micropollutants





Calculation of SMC



$$M_{event} = \sum C_{site} \cdot Q_{site} \cdot \mathrm{t}$$

$$Q_{site} = Q_{\mathrm{overflow}} + Q_{WWTP} + Q_{CSO}$$

$$Q_{street} = \frac{R_{event}}{10000} \cdot \alpha \cdot A_{street}$$

$$C_{washoff} = \frac{M_{event}}{Q_{street}}$$

$$SMC = median\left(C_{washoff}\right)$$

Dilution Factor

$$DF = \frac{\sum Q_{outfall}}{Q_{river}}$$