Assessing the contribution of wet-weather discharges on (micro-)pollutants release by urban catchments

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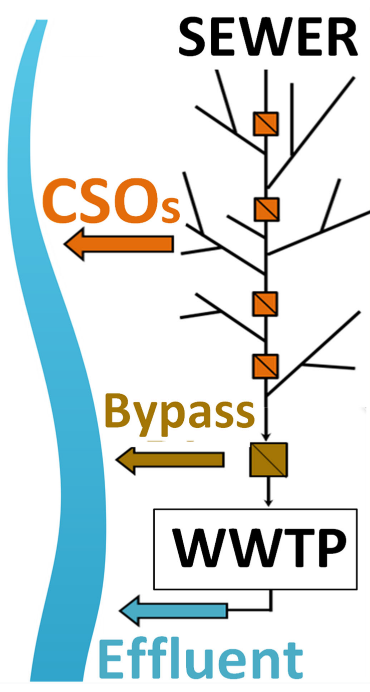
INTRODUCTION

›Intense rainfall events: activation of **Combined Sewer Overflows** (CSOs) and **Bypass** of the WWTP (BP)

›**"Good"** ecological and chemical **status** in **natural waters** required by 2027[1]

›**Wet-weather discharges:** major cause of **degradation** of surface water quality compared to WWTP effluent,[2] including **chronic risk** for **micropollutants**[3]

›**Concentration** of (micro-)pollutants in wet-weather discharges: **large variability** in time and space[2]



GAP

›Discharge of WWTP **bypass**

›**Volumes** released by wet-weather discharges of an **entire** sewer system

›**Environmental chronic risk assessment** caused by wet-weather discharges

AIM OF THE WORK

1. Which **discharge** and class of **pollutants** pose the highest **environmental chronic risk**?
2. How can different **choices** in the **risk assessment procedure** affect the result?

METHODS

SINGLE IUWS

DATA COLLECTION

For each *i-th* discharge type:

1. Water **quantity**: V_i, Q_R
2. Water **quality** for *j-th* (micro-)pollutants: $C_{i,j}$

3 **PAH**, Polycyclic Aromatic Hydrocarbons

3 **HM**, Heavy Metals

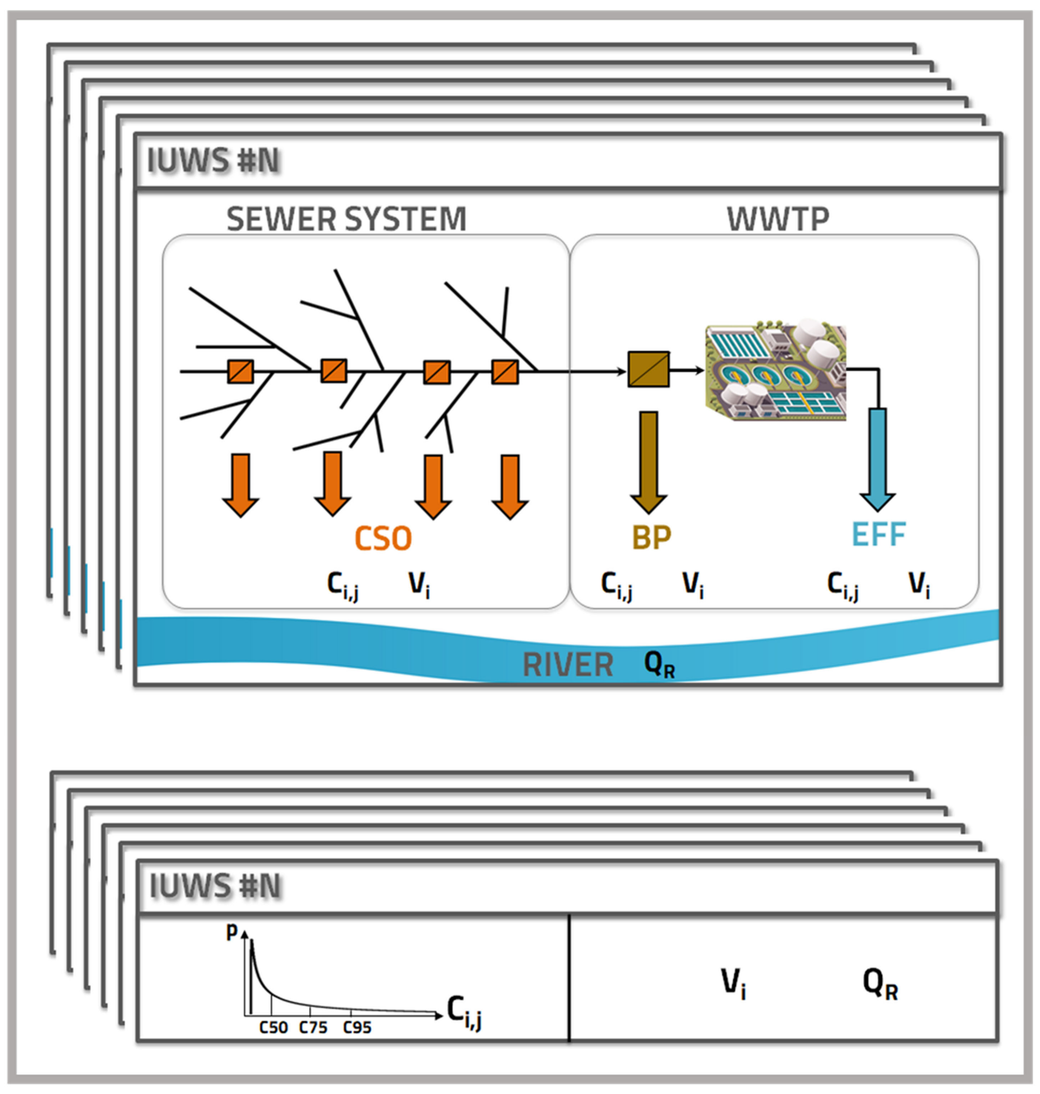
3 **PHARM**, Pharmaceuticals

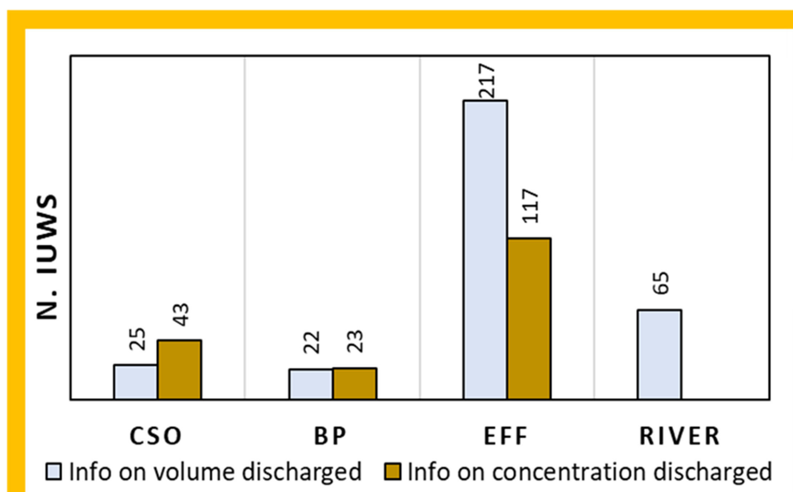
3 **PEST**, Pesticides

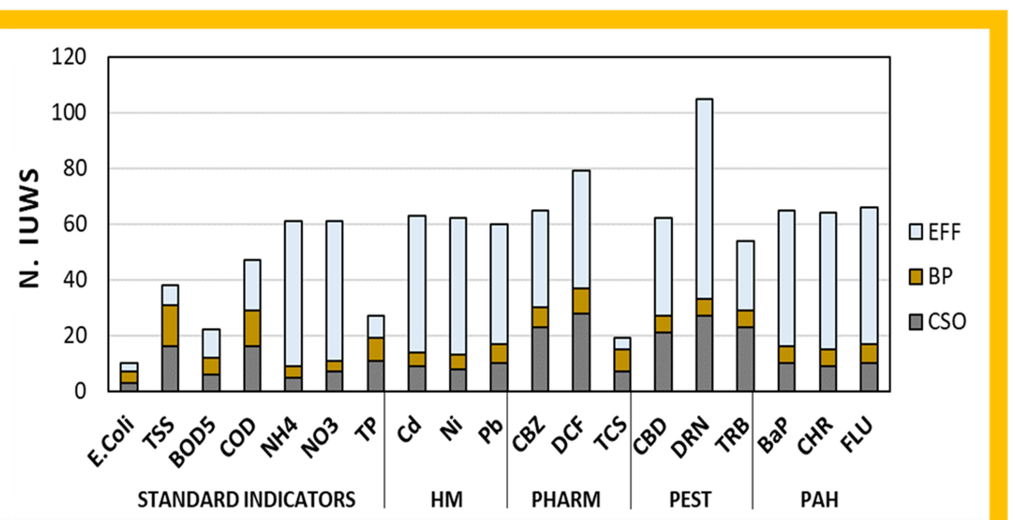
6 **Standard indicators**

PARAMETERIZATION

Fitting distributions to data ($C_{i,j}$)







ARCHETYPE IUWS

STOCHASTIC APPROACH

PARAMETERIZATION

Definition of **scenarios**:

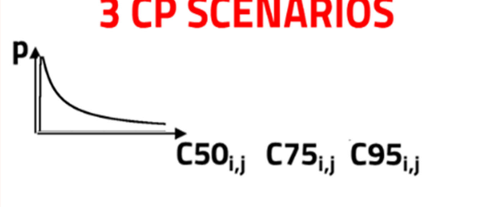
- **Concentration** Percentile (CP)
- **Dilution Factor** (DF)

ENVIRONMENTAL CHRONIC RISK ASSESSMENT

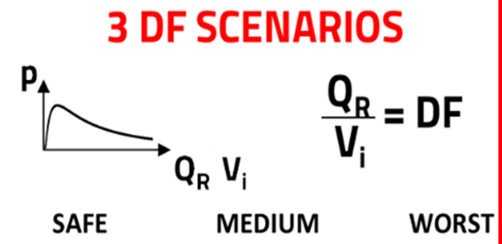
Risk Quotient (**RQ**) distribution

1. Macro-descriptors Pollution Level (**LIM**)

3 CP SCENARIOS

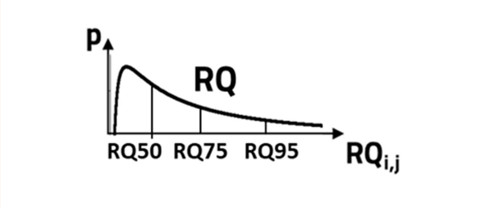


3 DF SCENARIOS

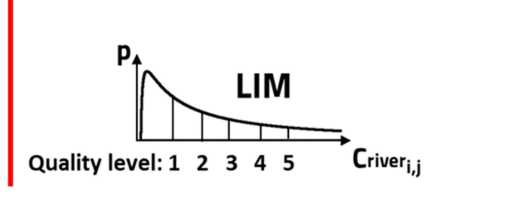


$\frac{Q_R}{V_i} = DF$

12 MICROPOLLUTANTS



6 STANDARD INDICATORS



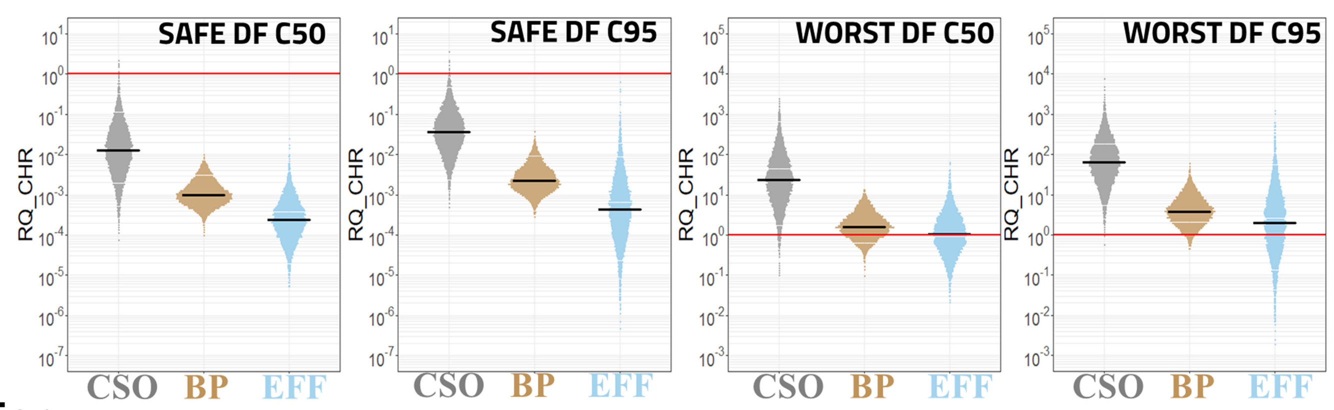
RESULTS

MICROPOLLUTANTS

› **Dilution factor** can impact **significantly**

› **No** significant **differences** in **RQ** when using **different percentiles** of the distribution of pollutant **concentration**

Distribution of RQ for Chrysene in each discharge for different scenarios



› **Higher risk** by **CSOs**, with micropollutants in the **order:** PAH>HM>PHARM>PEST

› **PAH** mainly cause the risk across all scenarios, due to **wet-weather** discharges (CSOs+BP)

› In the **effluent PHARM** is the class posing the highest risk to river

› **BP** is the discharge posing the **lowest risk** for the river

› **Significant differences** in risk assessment depending on the selected RQ percentile

Number of micropollutants exceeding the threshold RQ=1 for each discharge and scenario

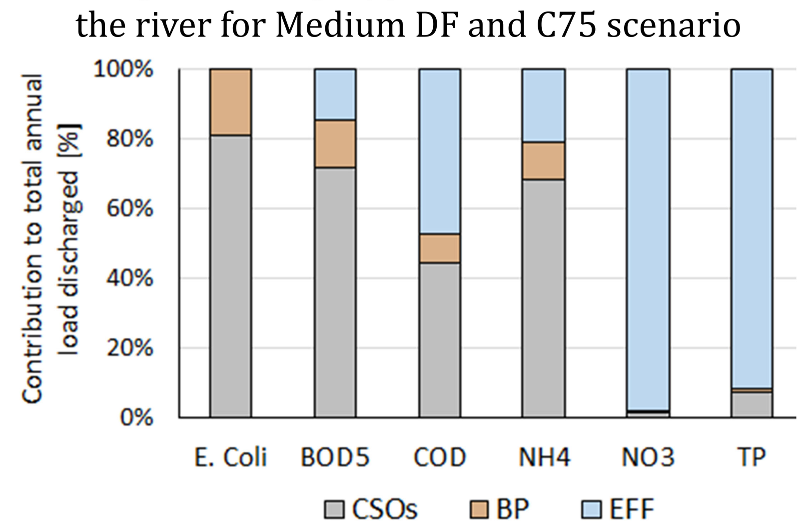
SCENARIOS			$n_{RQ_{i,j}>1}$				$n_{RQ_{i,j}>1}$				$n_{RQ_{i,j}>1}$		
DF	CP	RQP	CSOs	BP	EFF	DF	CSOs	BP	EFF	DF	CSOs	BP	EFF
SAFE	C50	RQ50	0	0	0	MEDIUM	1 PAH	0	0	WORST	3 PAH 2 PHARM 2 HM 2 PEST	3 PAH	3 PAH 3 PHARM 1 HM 1 PEST
		RQ75	0	0	0		2 PAH	0	1 PHARM		ALL	3 PAH 1 PHARM	ALL
		RQ95	1 PAH	0	0		3 PAH 1 HM	1 PAH	3 PHARM		ALL	3 PAH 3 PHARM 1 HM	ALL
	C75	RQ50	0	0	0		1 PAH	0	0		3 PAH 3 PHARM 3 HM 2 PEST	3 PAH	3 PAH 3 PHARM 1 HM 3 PEST
		RQ75	0	0	0		2 PAH	1 PAH	1 PHARM		ALL	3 PAH 2 PHARM 1 HM	ALL
		RQ95	1 PAH	0	0		3 PAH 1 PHARM 2 HM 1 PEST	1 PAH	3 PHARM 1 PAH		ALL	3 PAH 3 PHARM 1 HM	ALL
	C95	RQ50	0	0	0		2 PAH	1 PAH	0		3 PAH 3 PHARM 3 HM 2 PEST	3 PAH 2 PHARM 1 HM	3 PAH 3 PHARM 2 HM 3 PEST
		RQ75	1 PAH	0	0		3 PAH 1 HM	1 PAH	2 PHARM		ALL	3 PAH 2 PHARM 1 HM	ALL
		RQ95	1 PAH	0	0		3 PAH 2 PHARM 2 HM 2 PEST	1 PAH	1 PAH 3 PHARM		ALL	3 PAH 3 PHARM 1 HM 1 PEST	ALL

STANDARD INDICATORS

› The standard indicators **mainly released** by **wet-weather** discharges on an annual basis are ***E. coli***>BOD_5>NH_4>COD

› The release of NO_3 and **TP** is almost entirely related to **the effluent**

Contribution of single discharge types to total annual load discharged to the river for Medium DF and C75 scenario



› **CSOs** and **EFF** equally determine a **worsening** of the ecological status

› **Neglecting wet-weather** discharges for the evaluation of LIM will result in an **underestimation** of the ecological status

Quality level (LIM) in the river for each discharge type, DF scenario and C75

Quality level		Discharges			LIM
Scenario					
DF	CP	CSOs	BP	EFF	
SAFE	C75	1	1	1	1
MEDIUM	C75	2	1	2	3
WORST	C75	4	3	4	5

CONCLUSIONS

› There is a high impact of CSOs on chronic environmental risk in receiving water bodies
› The highest impact is related to the release of micropollutants: PAH>HM>PHARM>PEST
› PHARM in the effluent cause a significant risk already in the Medium DF scenario, but only in the Worst one during wet-weather
› Wet-weather discharges, and CSOs in particular, should not be neglected to properly address chronic environmental risk

REFERENCES

1. EU (2000) Water Framework Directive, Directive 2000/60/EC, European Parliament and Council, 23/10/2000
2. L. Mutzner, C. Bohren, S. Mangold, S. Bloem and C. Ort, Spatial Differences among Micropollutants in Sewer Overflows: A Multisite Analysis Using Passive Samplers, *Environ. Sci. Technol.*, 2020, **54**, 6584–6593.
3. E. Gooré Bi, F. Monette, J. Gasperi and Y. Perrodin, Assessment of the ecotoxicological risk of combined sewer overflows for an aquatic system using a coupled "substance and bioassay" approach, *Environ. Sci. Pollut. Res.*, 2015, **22**, 4460–4474.

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