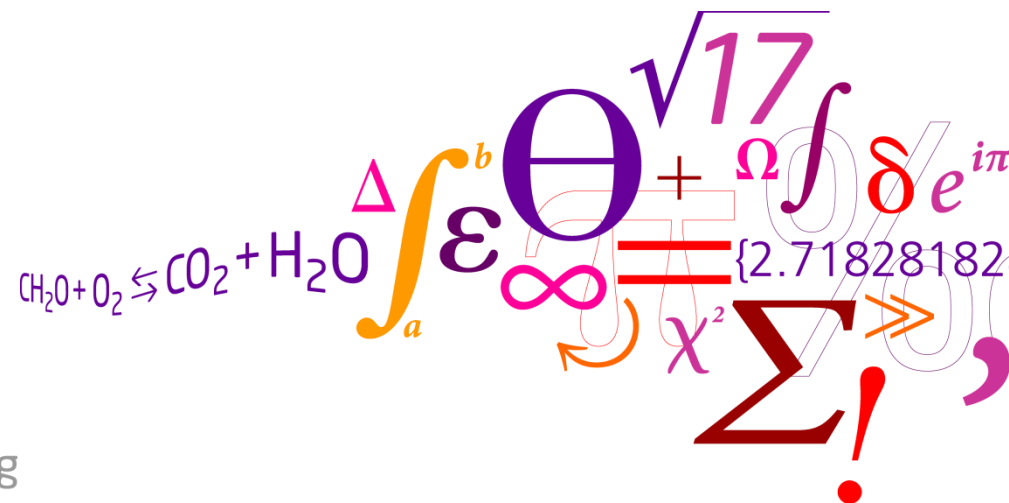


# Model based prediction of micropollutants fluxes in stormwater treatment systems

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# Introduction

- Focus on nonpoint source (diffuse) pollution is increasing
  - Focus on stormwater treatment is increasing
- Tool to reduce Micropollutants (MPs) discharge from stormwater*



- MP removal potential is needed



- Models can estimate fate of MP in stormwater treatment systems



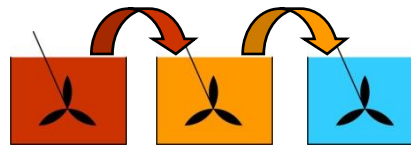
*What can we do about that?*

# The Stormwater Treatment Unit model for MicroPollutants (STUMP)

- Main concepts:

- Reuse of existing models

*Multi continuous stirred-tank reactor (CSTR) approach proposed by Wong et al. (2006)*



- Use of available information

MP's inherent properties → Public databases

Flow and TSS data → Easier to obtain

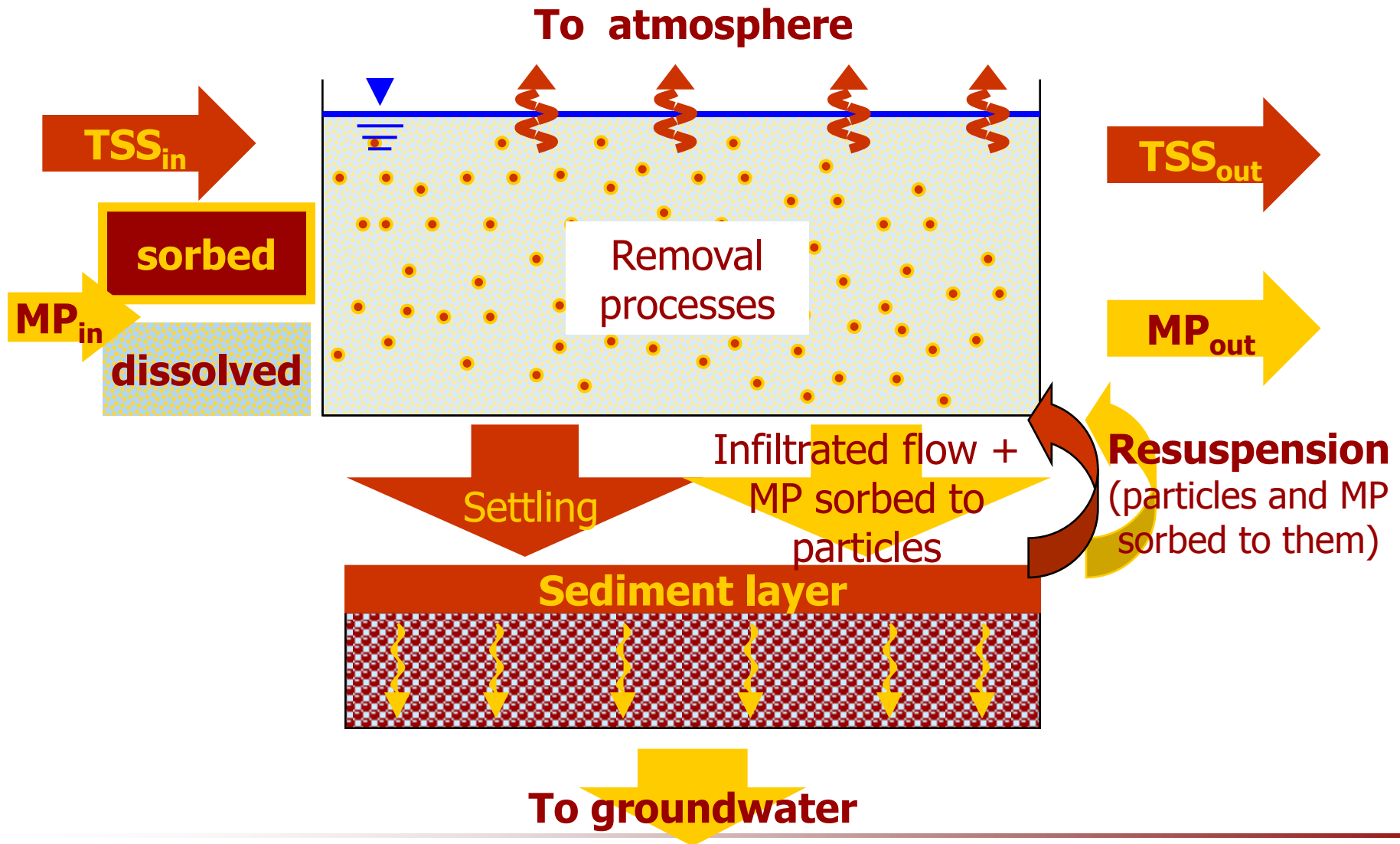
- Flexibility

Number of tanks → Hydraulic behaviour for different units

Inherent properties → Fate of different MPs

# Pollutant removal

## Conceptual model



# Selection of removal processes

## Physical processes

Source: Scholes et al. (2008)

- Filtration
- Settling
- Volatilization

## Physico-chemical processes

- Sorption
- Flocculation
- Hydrolysis
- Photolysis
- Precipitation

## Biological processes

- Microbial degradation
- Plant and algal uptake

# MP fate estimation

## Does STUMP works?

- Comparison of three multimedia models

- EPI Suite (USEPA, 2008)
- SimpleBox (den Hollander and van de Meent, 2004)
- STUMP

*Can we use these models to estimate MP fate in stormwater treatment?*

- Four different substances:

- IPBC\* → "Neutral"
- Benzene → Volatile
- Glyphosate → Biodegradable
- Pyrene → Sorbing

(\* ) 3-Iodo-2-propynyl butyl carbamate

# The Lilla Essingen case study

- Small catchment in Stockholm ( $\approx 1.2$  ha)
- Major pollutant source: traffic

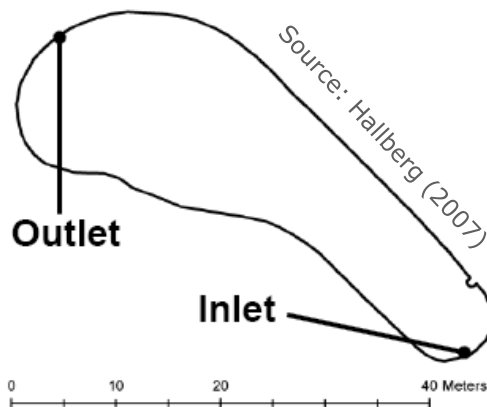


Source: Google Earth 2009



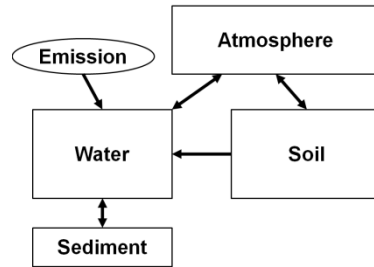
Source: Stockholm Vatten (2006)

- Permanent pond volume :  $150 \text{ m}^3$
- Hydraulic residence time  $\sim 69$  hr
- Water level: 0.9-1.4 m
- Water quality measured at inlet and outlet between May 2004-May 2005
- Measurements: "traditional" (e.g. TN, TP, etc.), heavy metals (total and dissolved)



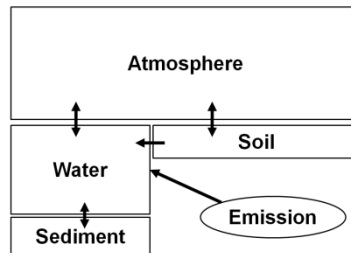
# Model Settings

## • EPI Suite



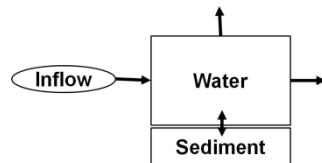
- Steady state
- Fixed size of compartment
- 1 dataset

## • SimpleBox



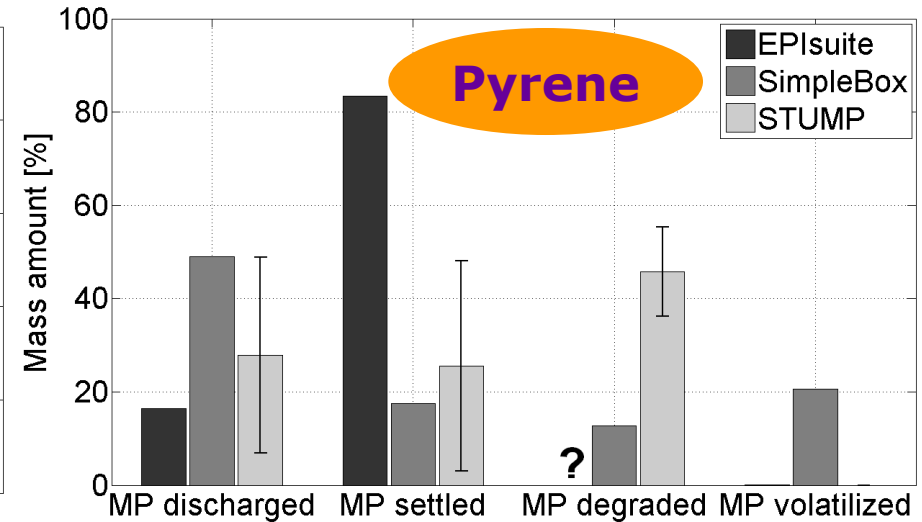
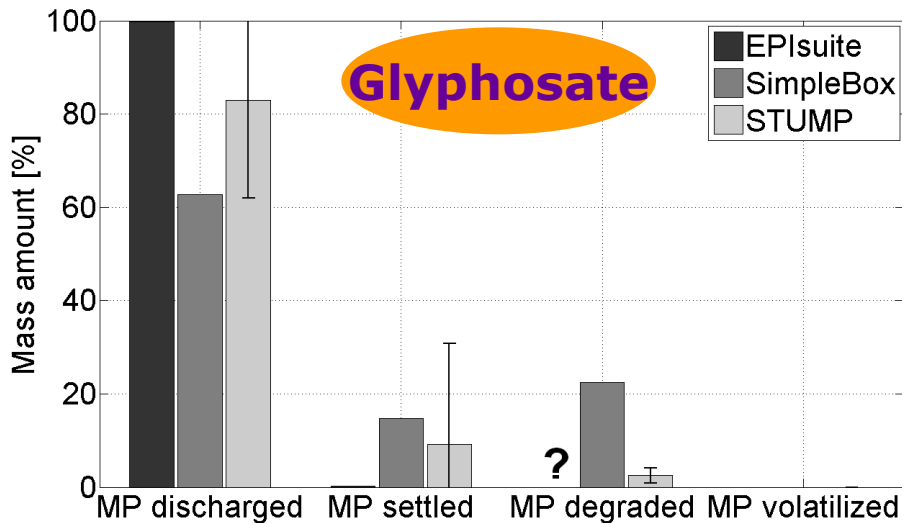
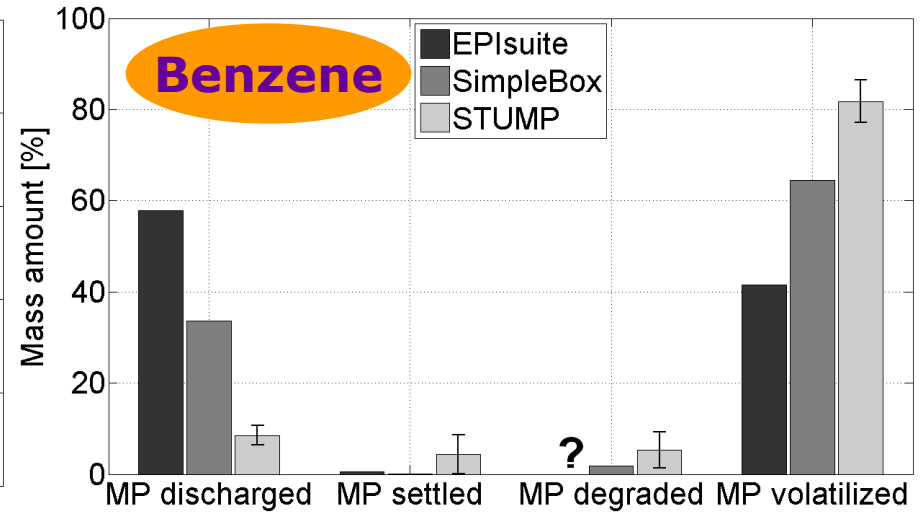
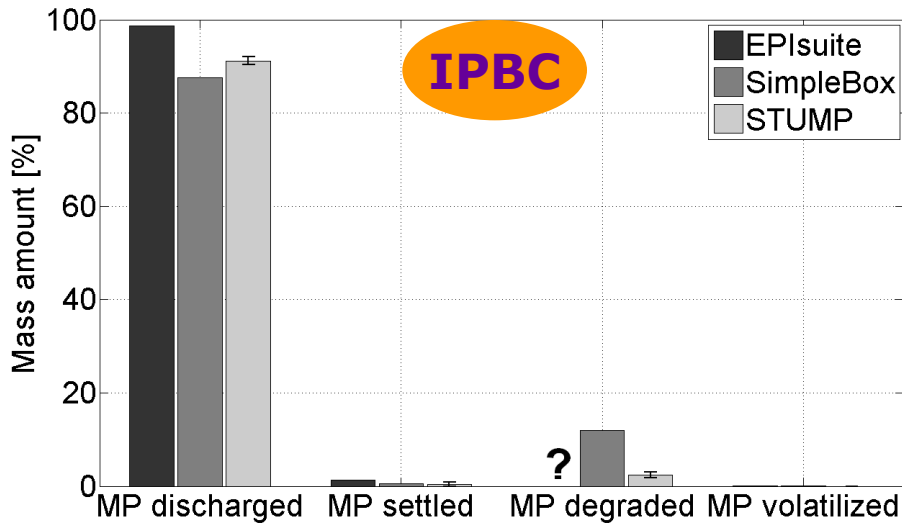
- Steady state
- Size of compartment adapted to Lilla Essingen
- 1 dataset

## • STUMP

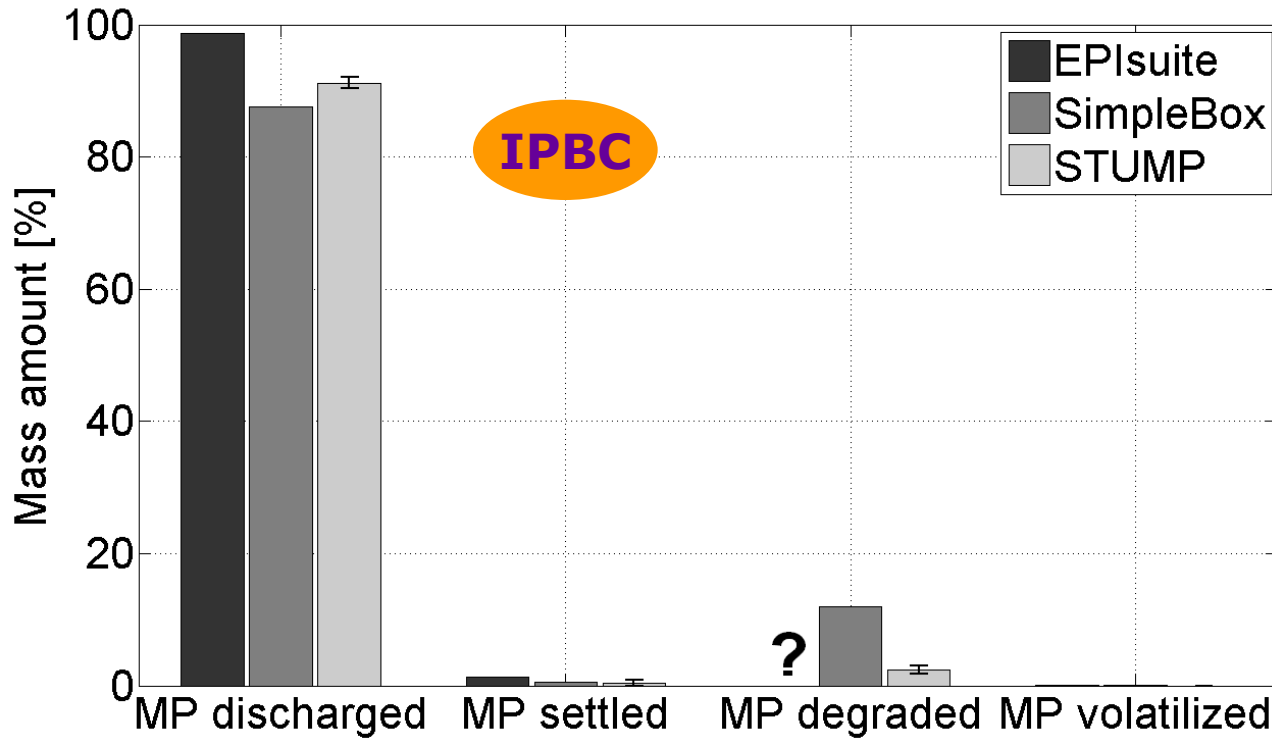


- Dynamic model
- Variable size of compartments
- 240 datasets sampled from literature distributions

# Simulated mass distribution



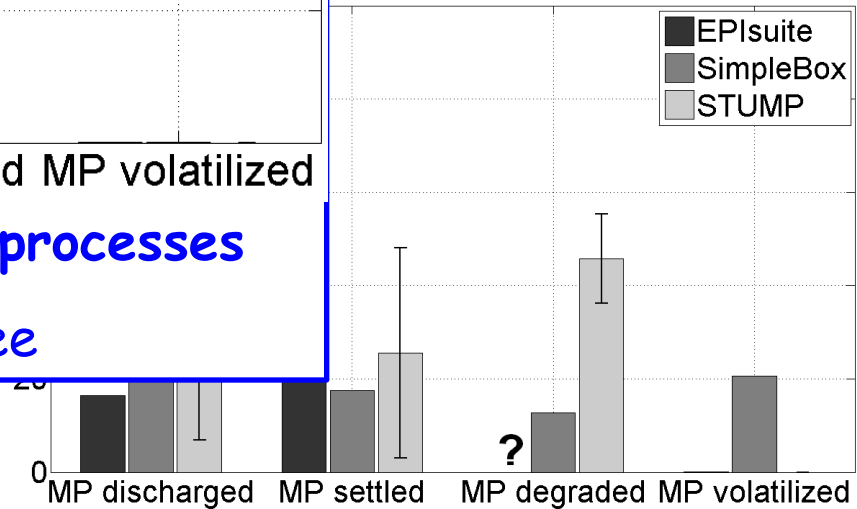
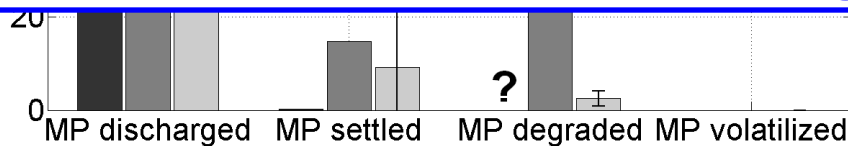
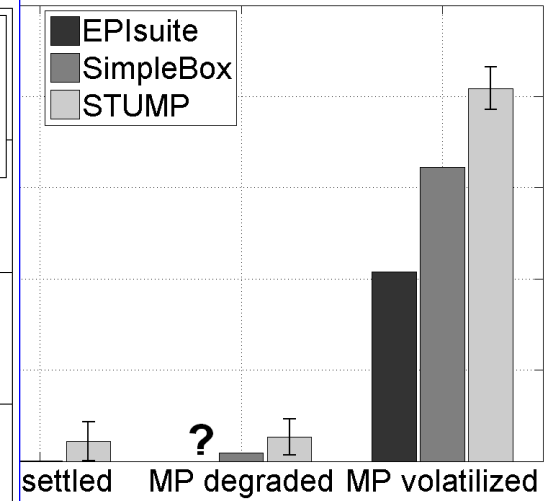
# Simulated mass distribution



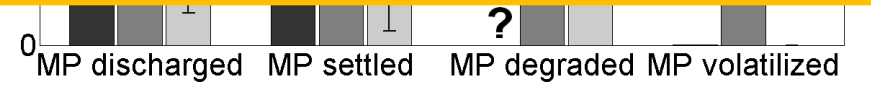
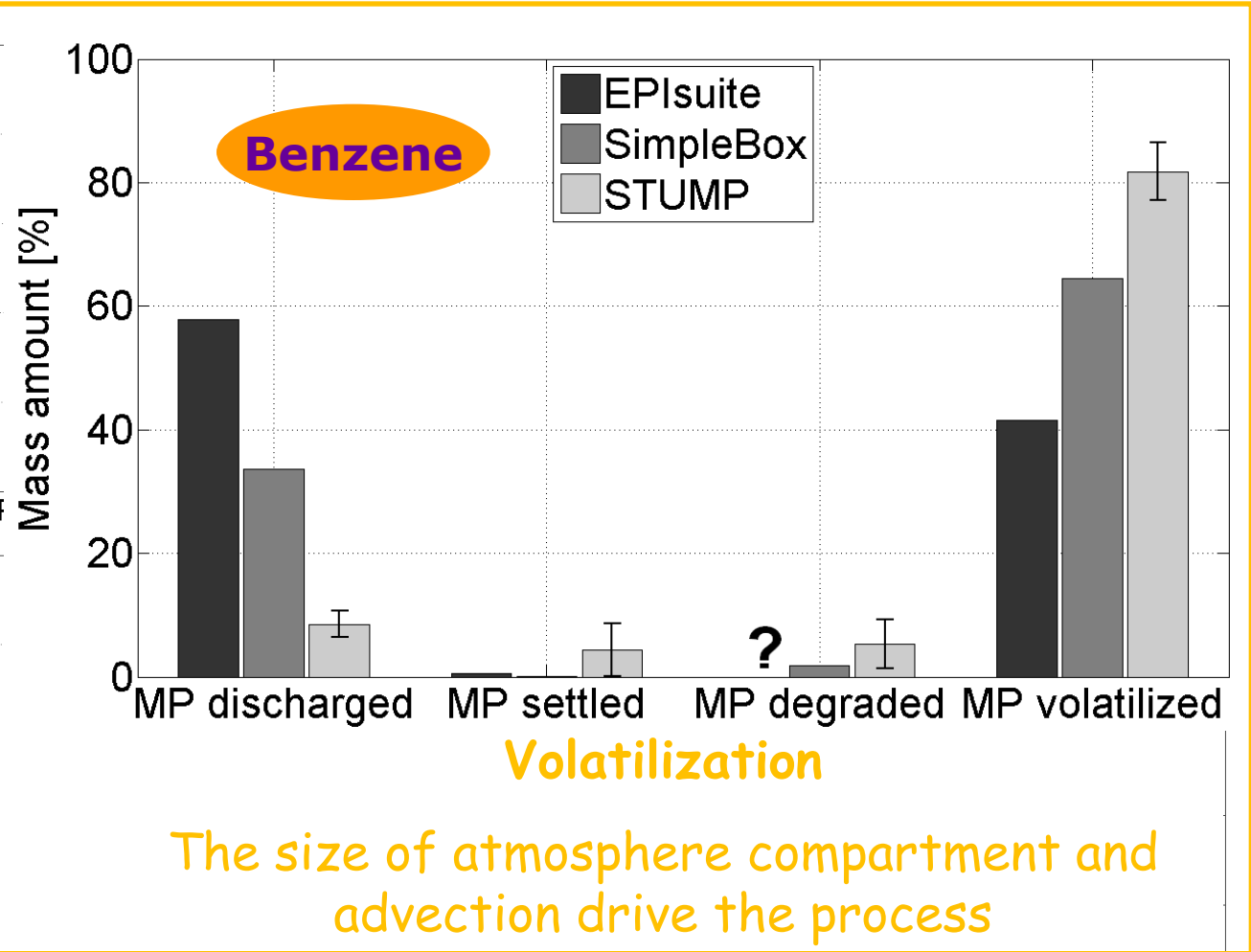
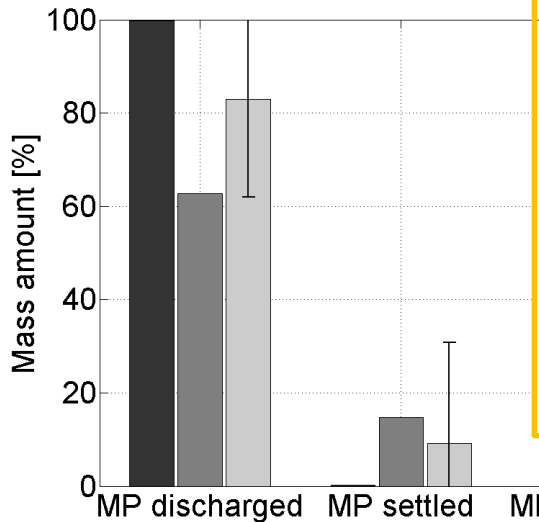
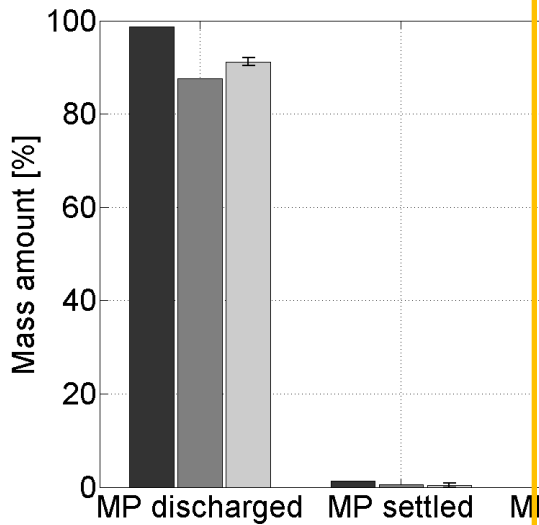
**IPBC**

Neutral substance = no fate processes

The three models agree



# Simulated mass distribution

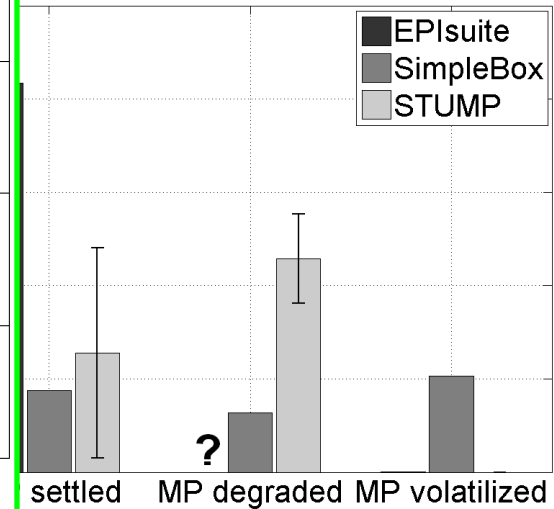
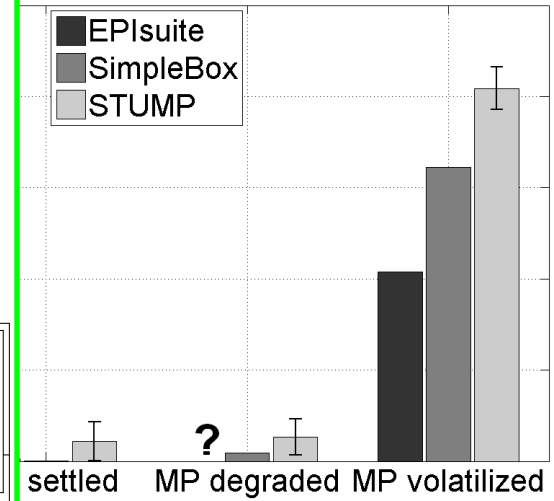
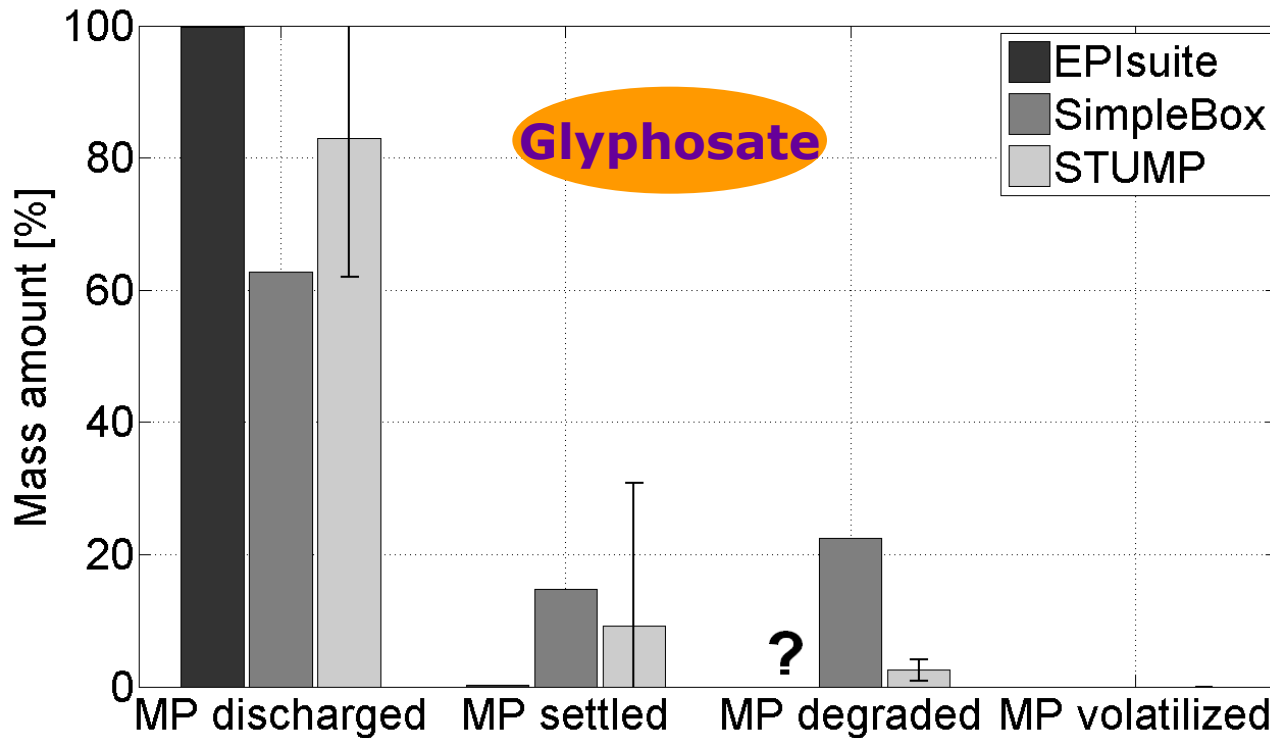


## Degradation/sorption

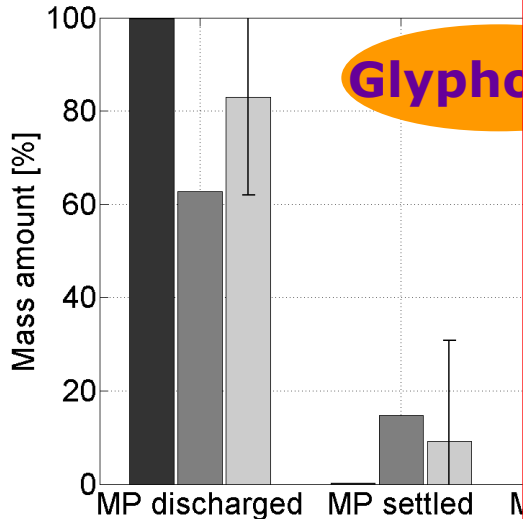
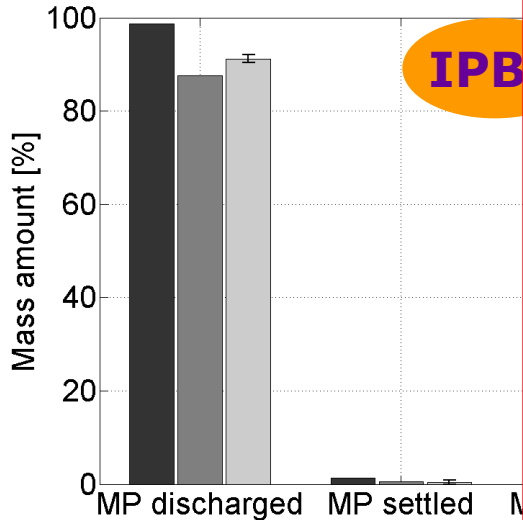
Multimedia models consider steady-state systems

Processes may not have time to reach equilibrium in the considered system

**Glyphosate**



# Simulated m

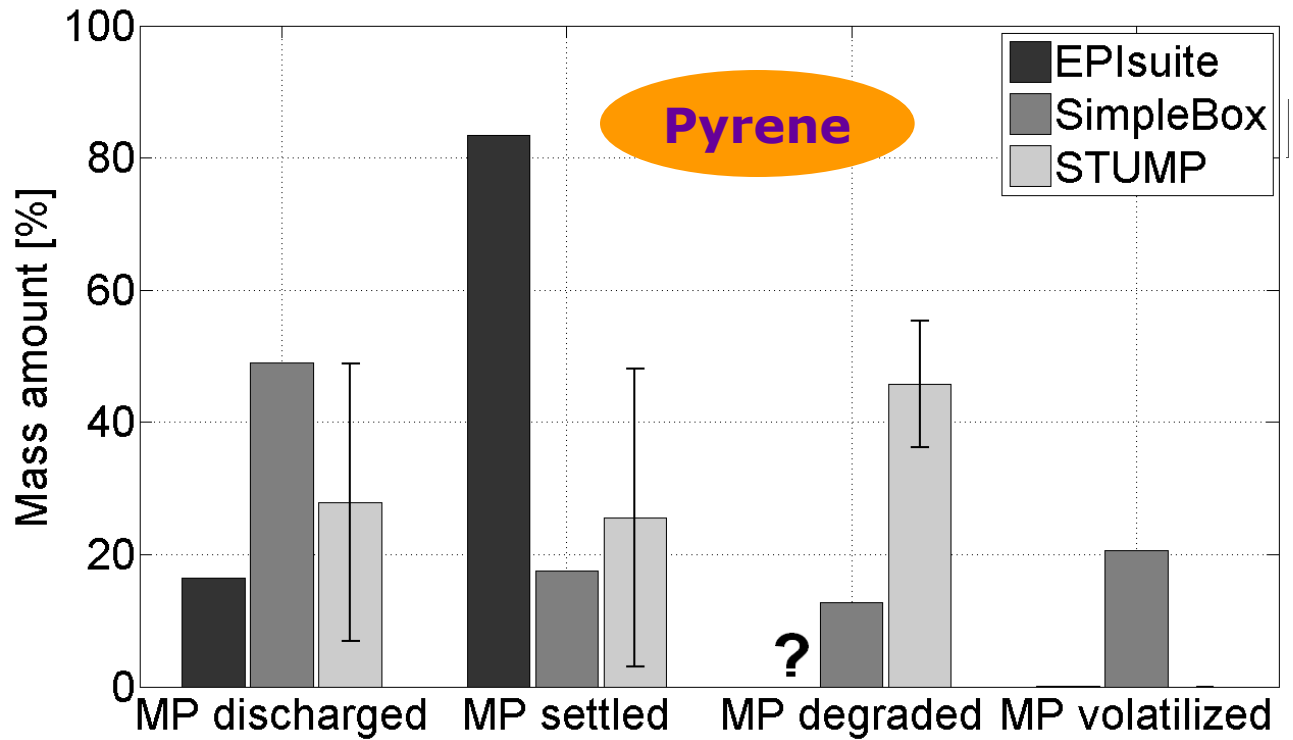


## Sorption / photodegradation

Uncertainty in model parameters influences results

Photodegradation rate: 1 value

sampled in  $\pm 1$  order of magnitude)



# Model based estimation of MPs

- Estimated MP fate were similar to those expected  
*(e.g. benzene goes to atmosphere)*
- Characteristics of the model affect the quantification of MP removal
  - Possibility of adapting the compartments to the analyzed system
  - Stormwater treatment works during rain events



Dynamic models are more realistic

*What if we actually have measurements?*

# STUMP uncertainty estimation

- Available data from Lilla Essingen
  - TSS measurements



*we can reduce the uncertainty on MP settling/resuspension  
(which is the most sensitive process in STUMP)*

- Heavy metals (dissolved and particulate)

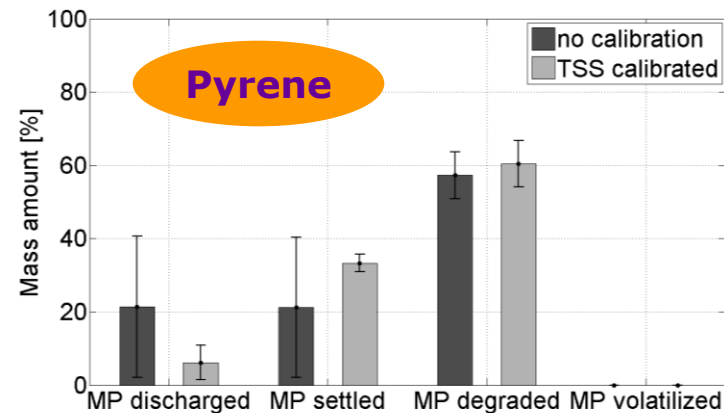
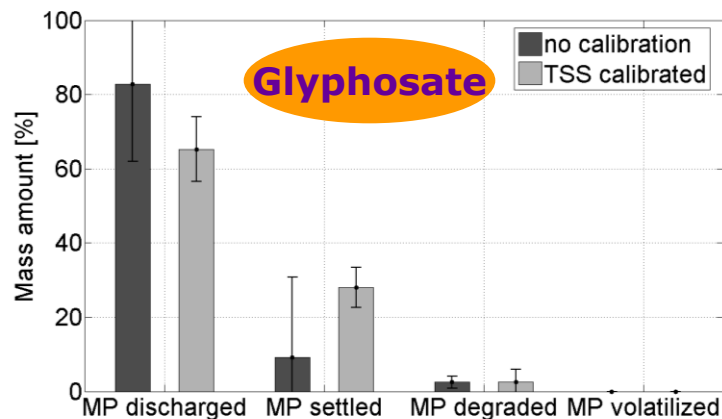
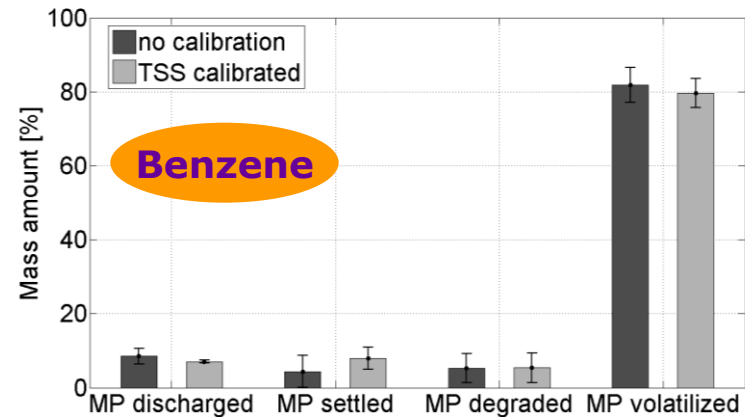


*We can estimate the uncertainty bounds of my model predictions*

# Uncertainty reduction

- TSS predictions optimized by using the GLUE methodology (Beven and Binley, 1992)

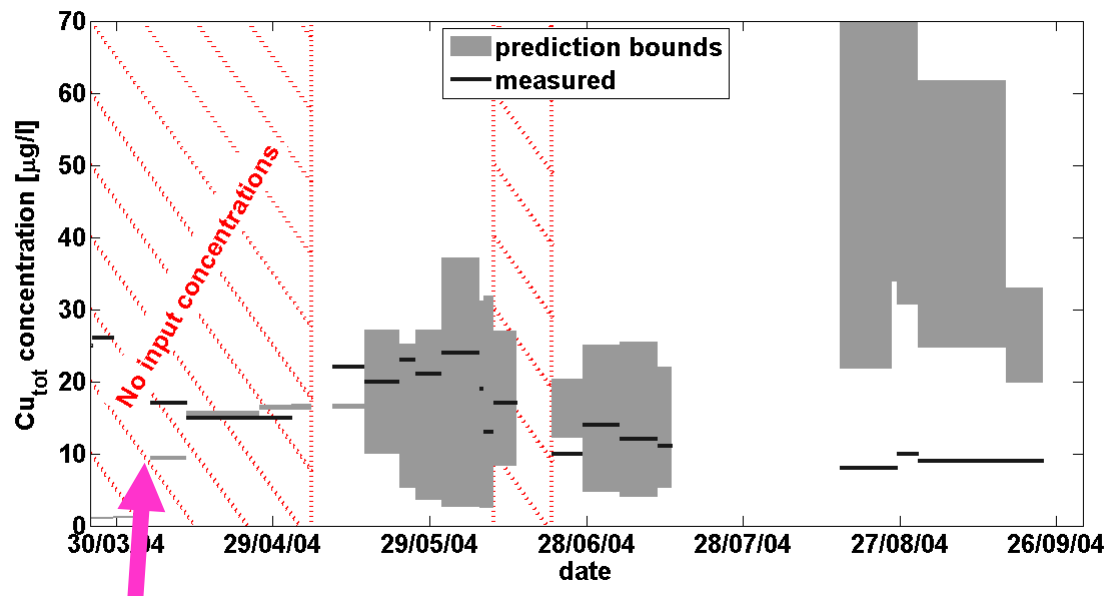
- No significant improvement for mainly dissolved substances
- Major improvement for MPs with higher tendency to sorb



# Uncertainty Analysis(1)

- Results for copper (Cu) and zinc (Zn)
  - Prediction bounds estimated with the GLUE methodology (Beven and Binley, 1992)

## Predicted Cu total outlet concentration



Measured output, but not measured input

# Uncertainty Analysis(2)

- Total Cu concentrations under/overestimated
- Pond removal efficiency (%)
  - Measured (9 inlet samples +16 outlet)

	May	Jun	Jul	Ago
Cu	99	92	60	97
Zn	99	93	64	97

- Modelled (190 days continuous output)

Cu ~ 92 %

Zn ~ 92 %

What is worse? The model or the measured data?

# Conclusions

- Multimedia fate models can be used to quantify the potential MP removal in stormwater treatment systems
- The dynamic STUMP model has a more realistic representation of the system than the two competing models
- STUMP can benefit from any additional measurements to reduce the output uncertainty
- Still to investigate: application and uncertainty in stormwater treatment units other than ponds, e.g., swales

# Acknowledgments

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- The authors also thank Antonio Franco for his support in the application of the SimpleBox software.