Removal capacity of slow sand filtration and riverbank filtration

Christian Skark, Frank Remmler, Ulrich Schulte-Ebbert and Ninette Zullei-Seibert

Institut für Wasserforschung GmbH
Zum Kellerbach 46
58239 Schwerte
Germany

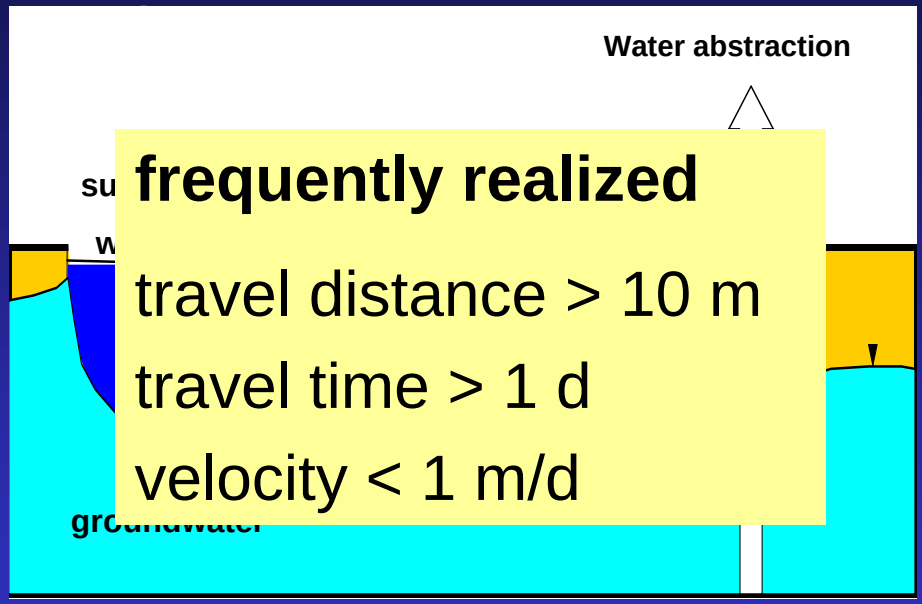
Outline

- near-natural treatment processes
- purification processes and removal capacity
  - → riverbank filtration
  - → slow sand filtration
- summary

Near-natural treatment steps

riverbank filtration

RBF



frequently realized

travel distance > 10 m

travel time > 1 d

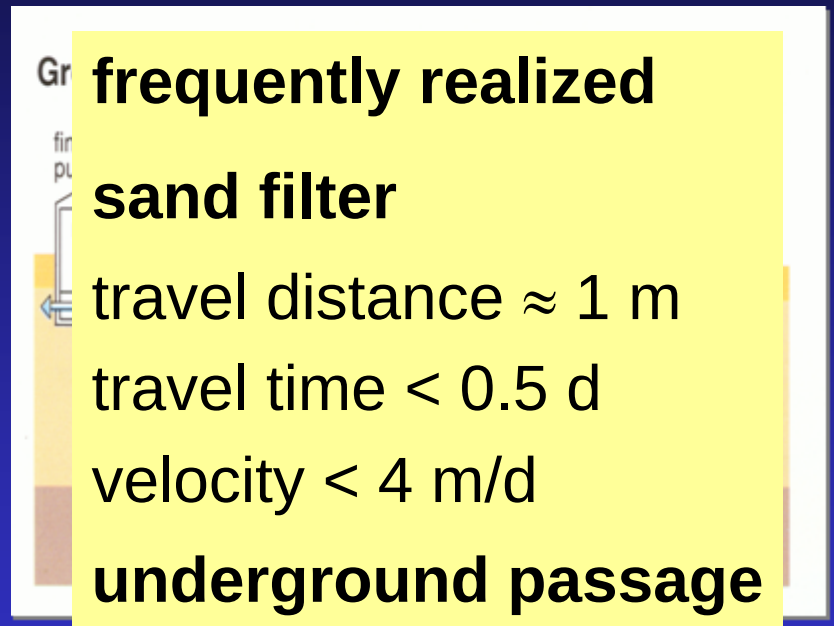
velocity < 1 m/d

Waterworks Düsseldorf-Flehe 1870

Waterworks Dresden-Saloppe 1875

Slow sand filtration

SSF



frequently realized

sand filter

travel distance ≈ 1 m

travel time < 0.5 d

velocity < 4 m/d

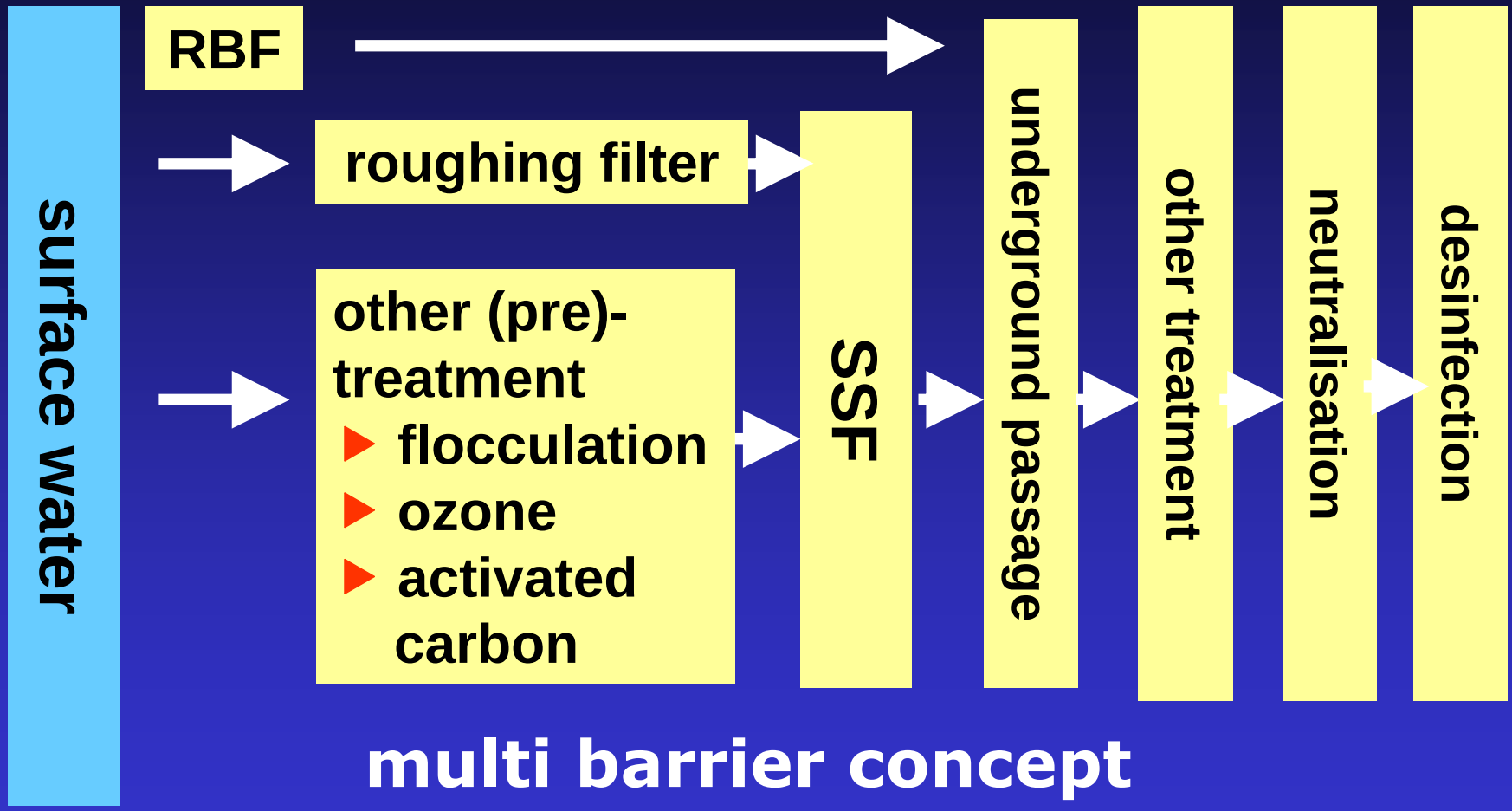
underground passage

travel distance > 50 m

travel time > 3 d

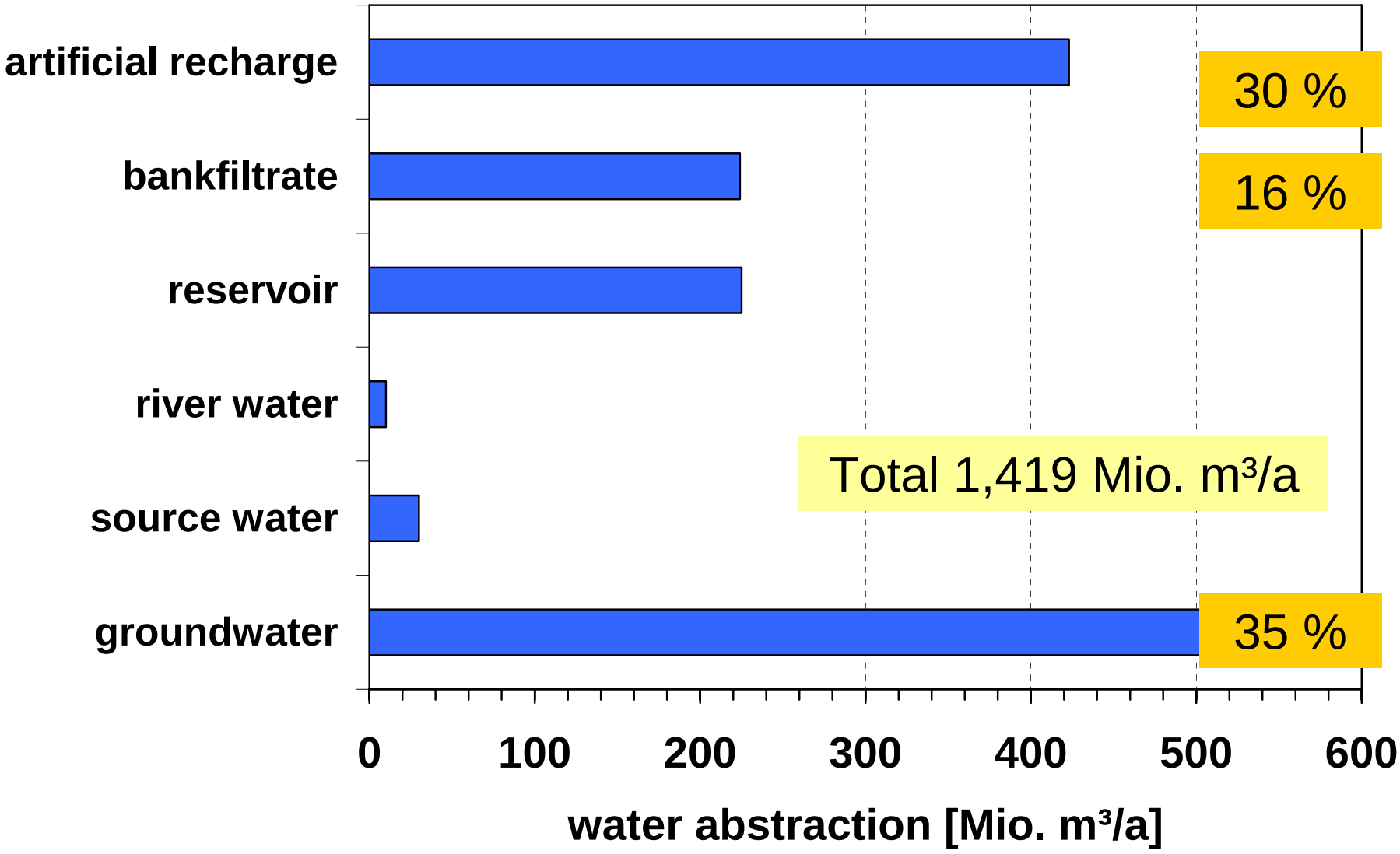
velocity < 1 m/d

Manifold combination of treatment steps



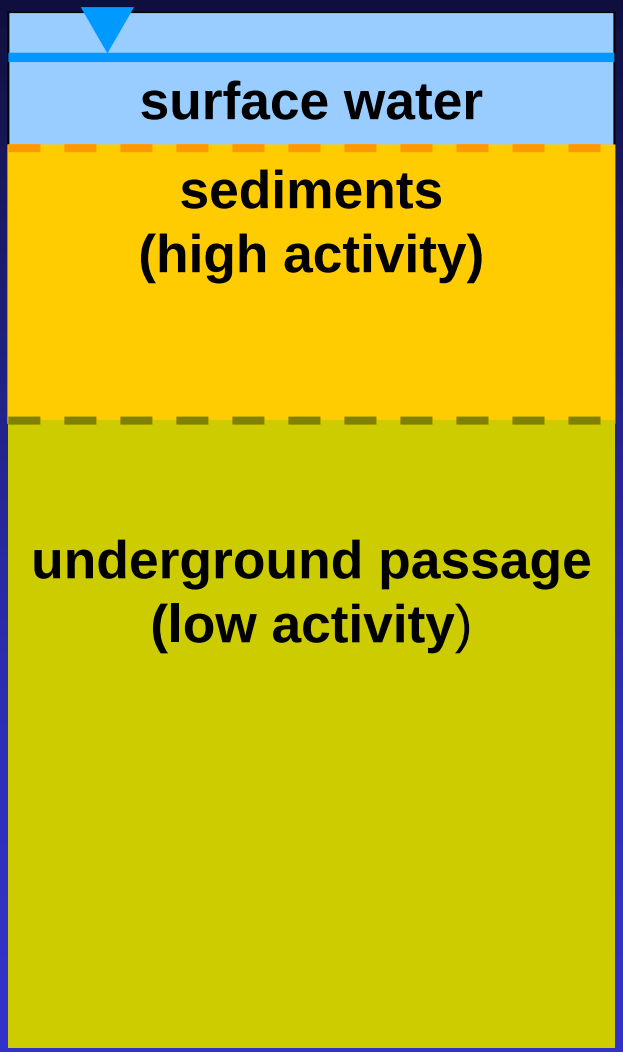
multi barrier concept
modular combination

Origin of drinkingwater in Northrhine-Westphalia



Source: MUNLV, Grundwasserbericht NRW 2000

Purification processes riverbank filtration



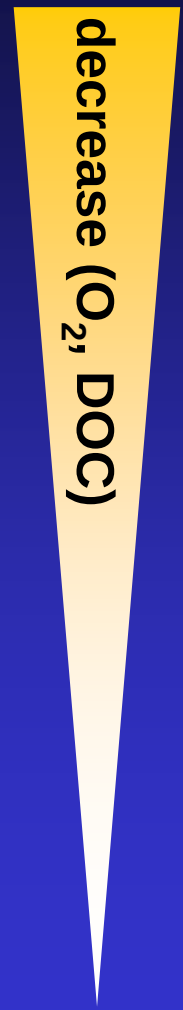
- sedimentation
- mechanical straining
- sorption
- degradation

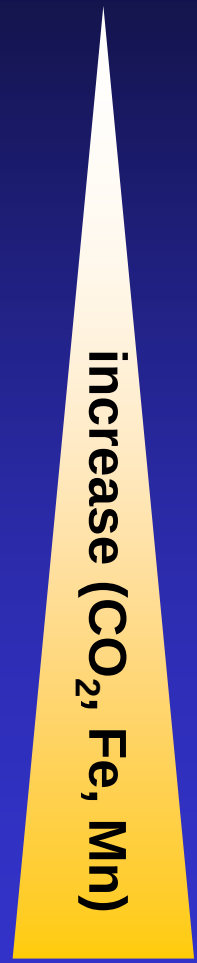
- precepitation

- solution
- desorption

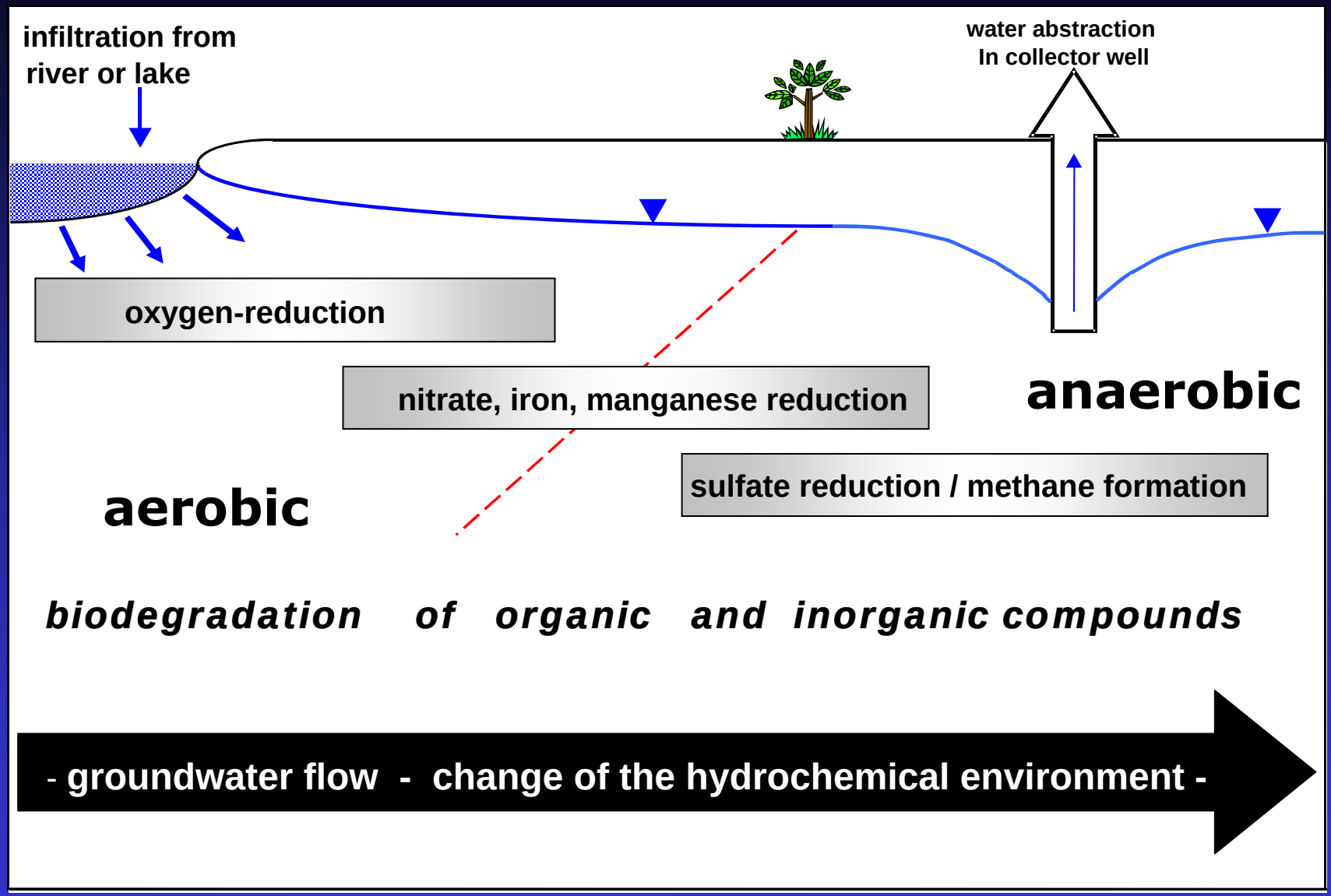
further purification during underground passage

Concentration change

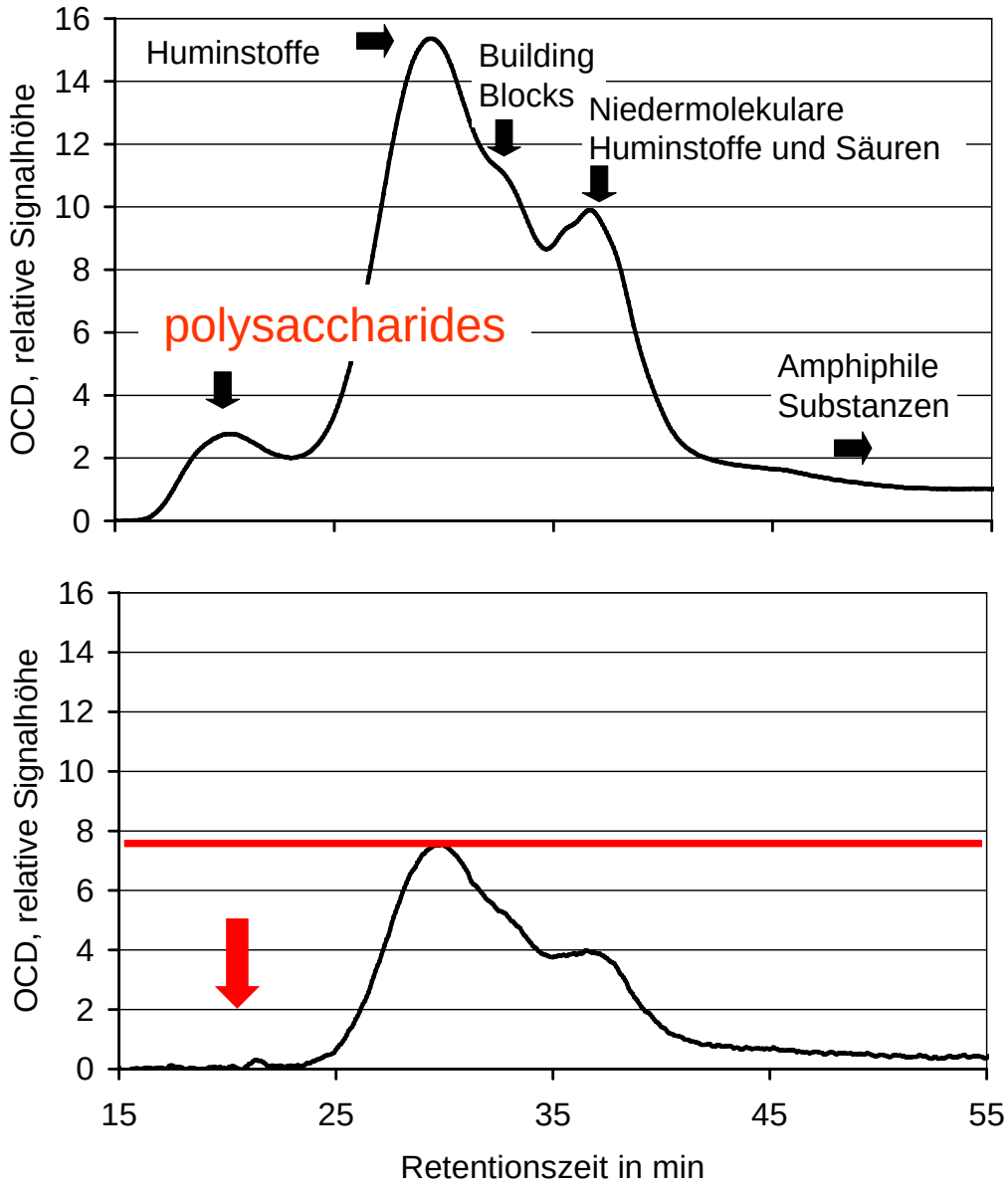




Bank filtration and underground passage



DOC-Fractions during bank filtration



Rhine

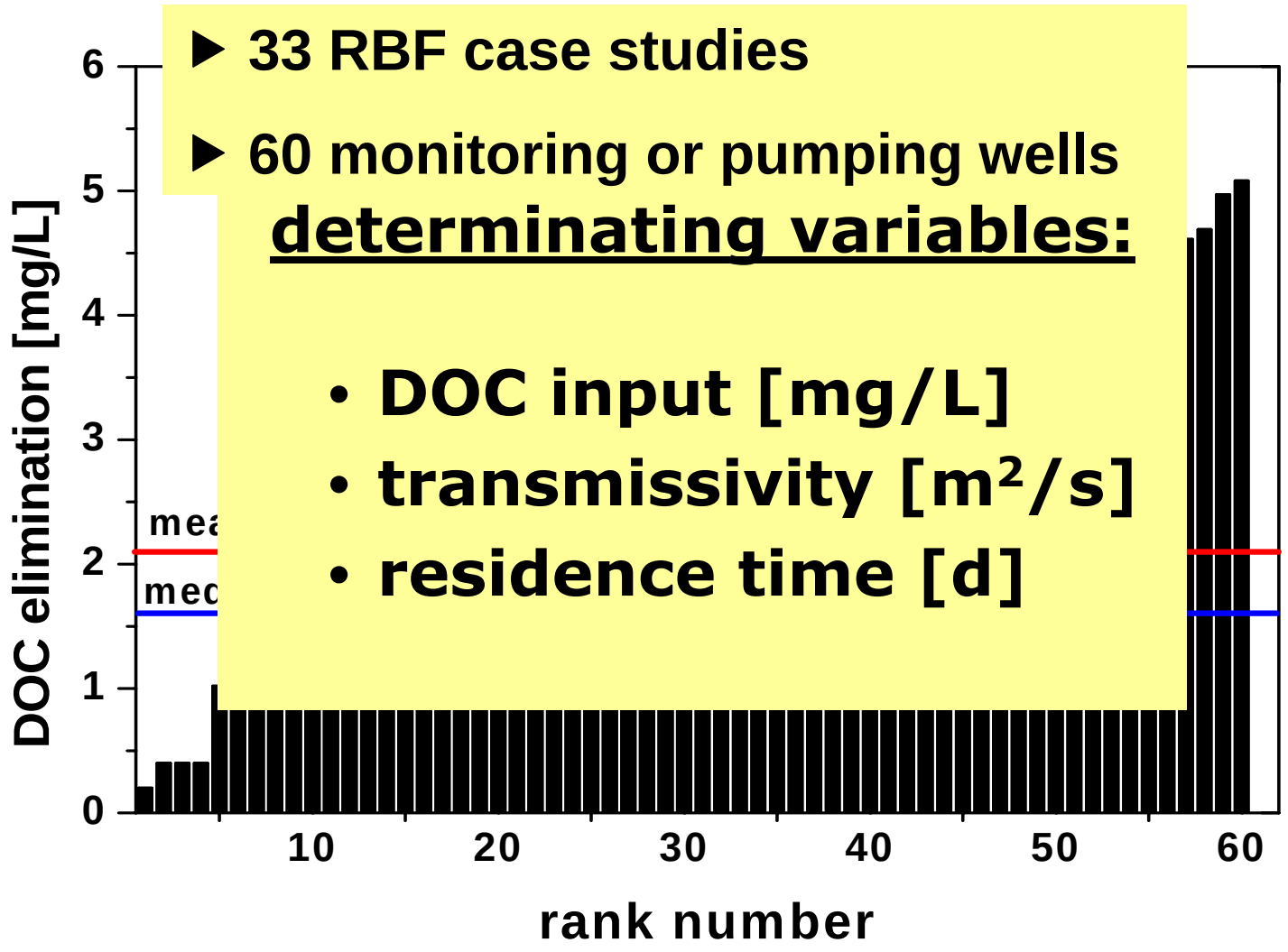
pumping well

(mean, n=10)

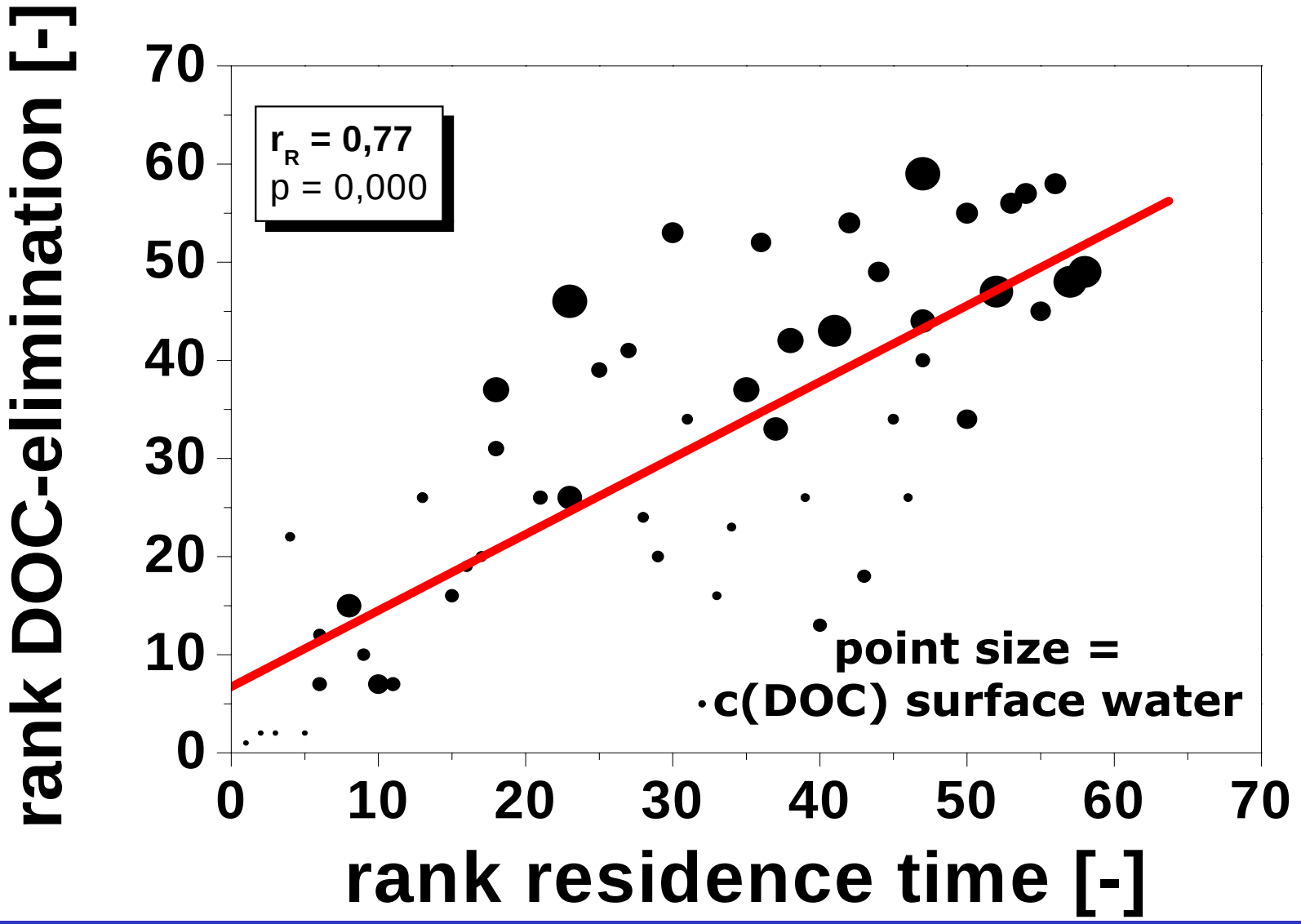
Marschke & Wichmann 2005

Removal capacity during bank filtration

elimination of DOC during underground passage



Multivariate influence on the DOC-elimination



Multiple regression models for the DOC-elimination

all sites

$$Y = -0.503 + 0.811 * \ln(X_1) + 0.236 * (X_2)^{0.437} + 7.428 * (X_3)$$

$R^2 = 0.74$

X_1 = DOC-concentration in surface water [mg/L]

X_2 = residence time in underground [d]

X_3 = transmissivity [m^2/s]

sites with aerobic underground passage

$$Y = -0.614 + 1.370 * \ln(X_1) + 0.026 * (X_2)^{0.937} + 4.856 * (X_3)$$

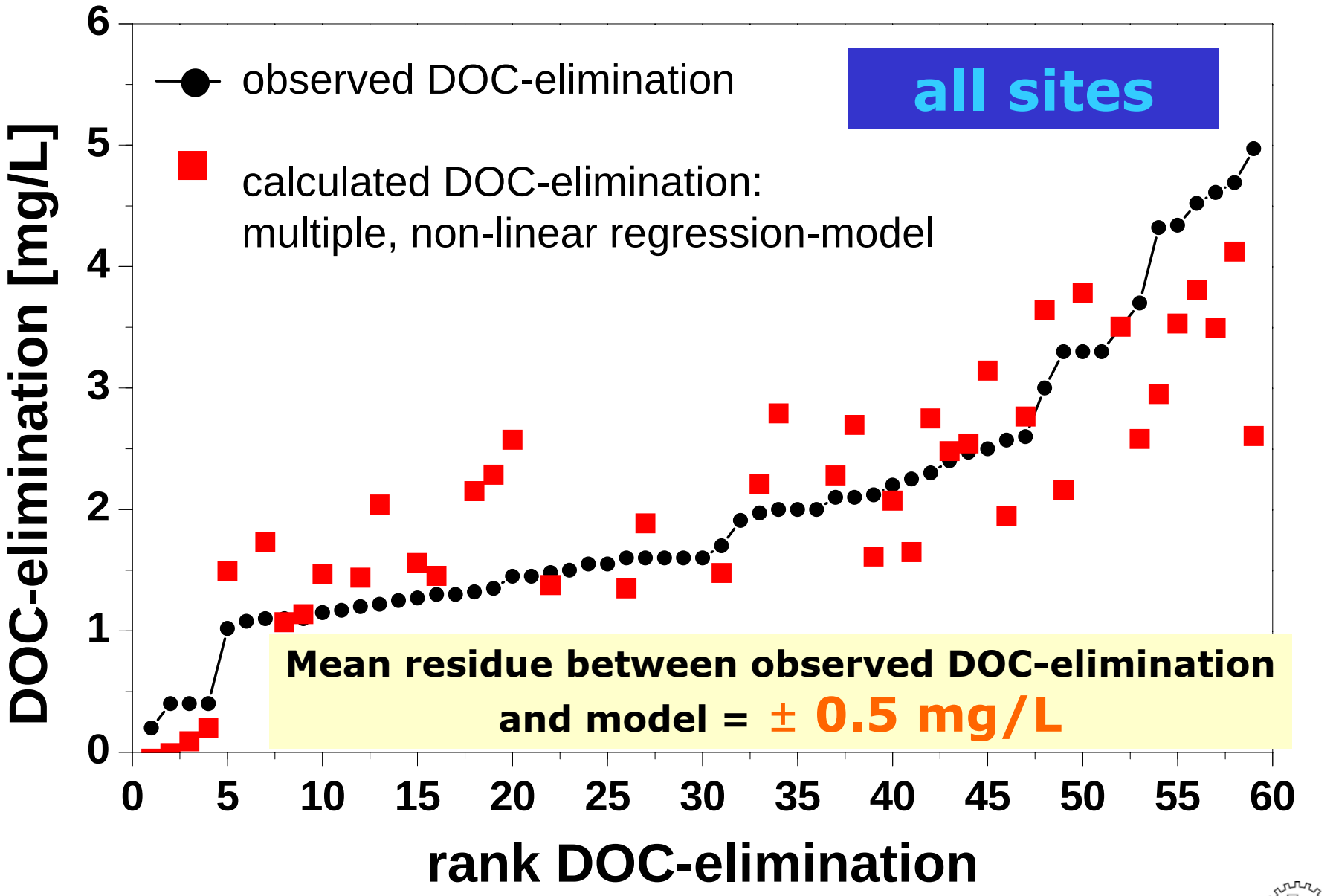
$R^2 = 0.87$

X_1 = DOC-concentration in surface water [mg/L]

X_2 = residence time in underground [d]

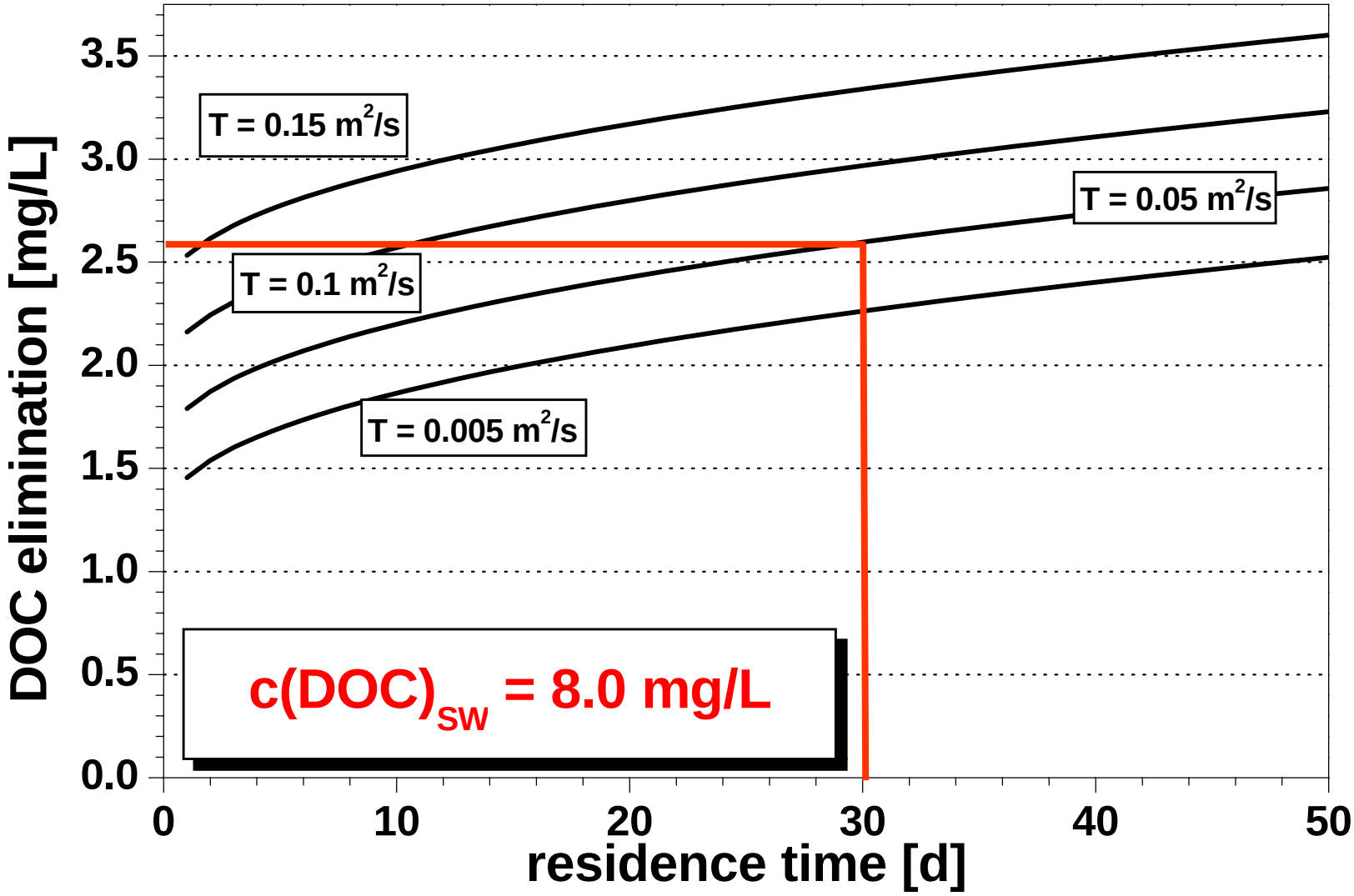
X_3 = transmissivity [m^2/s]

Multiple regression models for the DOC-elimination



Estimate of DOC – removal at a new site

nomogram - applied multivariate regression function



Trace compounds during bankfiltration

substance	aerobic	suboxic	anoxic	anaerobic
Complexing agents				
EDTA	++	++	o	o
NTA	++++	++++	++++	++++
Naphthalenesulfonates				
Naphthalene-2-sulfonate	++++	++++	++++	++++
Naphthalene-1				
Naphthalene-1				
Carbamazepin				
Diclofenac				
Sotalol				
Sulfamethoxaz				
Clindamycin				
Iopromid	++++	++++	++++	++++
Iopamidol	+	++	+++	++++
Amidotrizoesäure	o	o	+	++++

Problematic substances

- soluble
- weak sorption
- under a certain redox condition not degradable

o ≤ 25%, + ≤ 50 %, ++ ≤ 70 %, +++ < 80 %, ++++ > 80 % removal

Schmidt et al. 2006

Purification processes slow sand filter

aeration

- sedimentation
- mechanical straining
- sorption
- degradation

- precipitation

- solution
- desorption

further purificati
during undergrou
passage

Concentration change

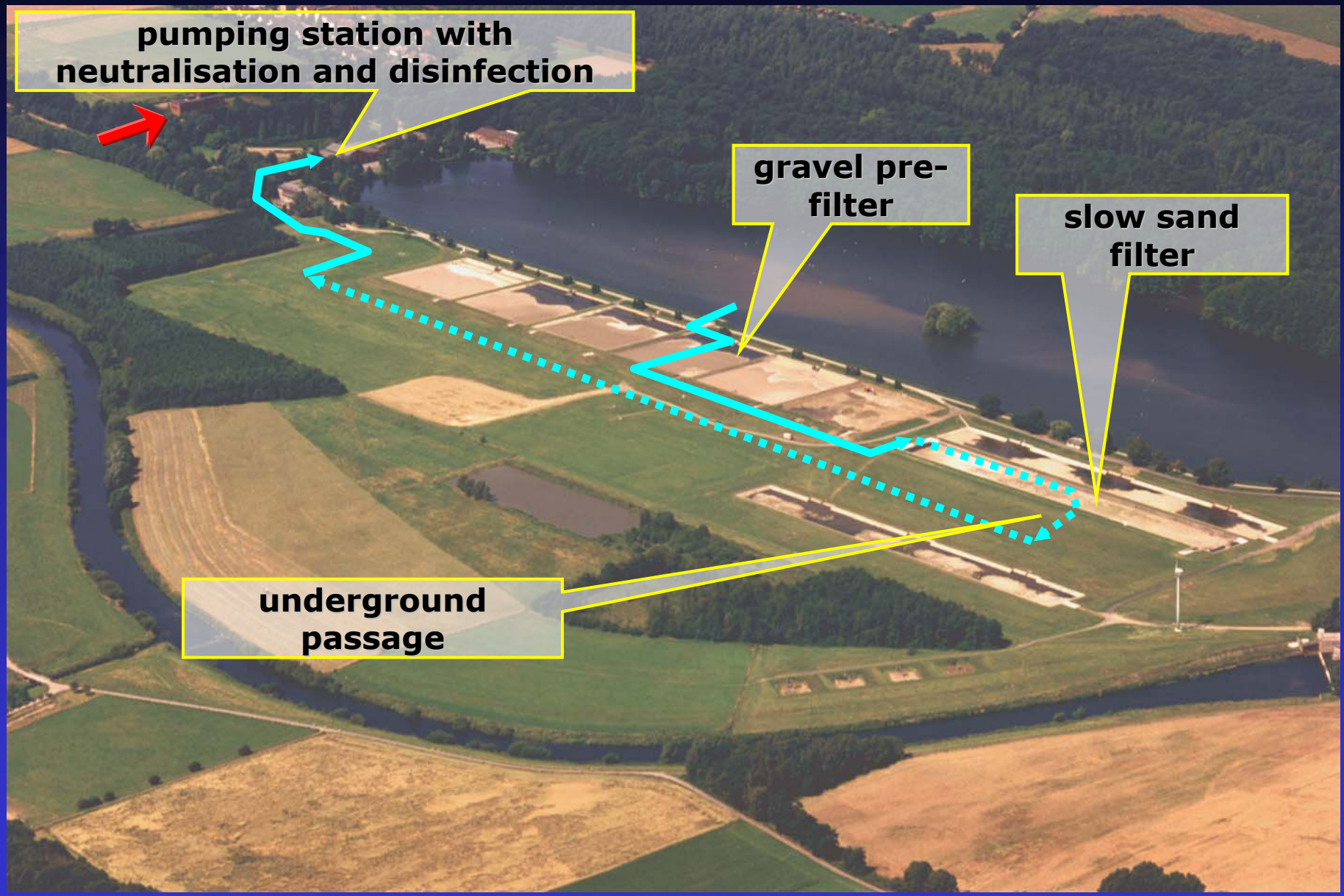
Aerobic degradation

decrease (O_2, DOC)

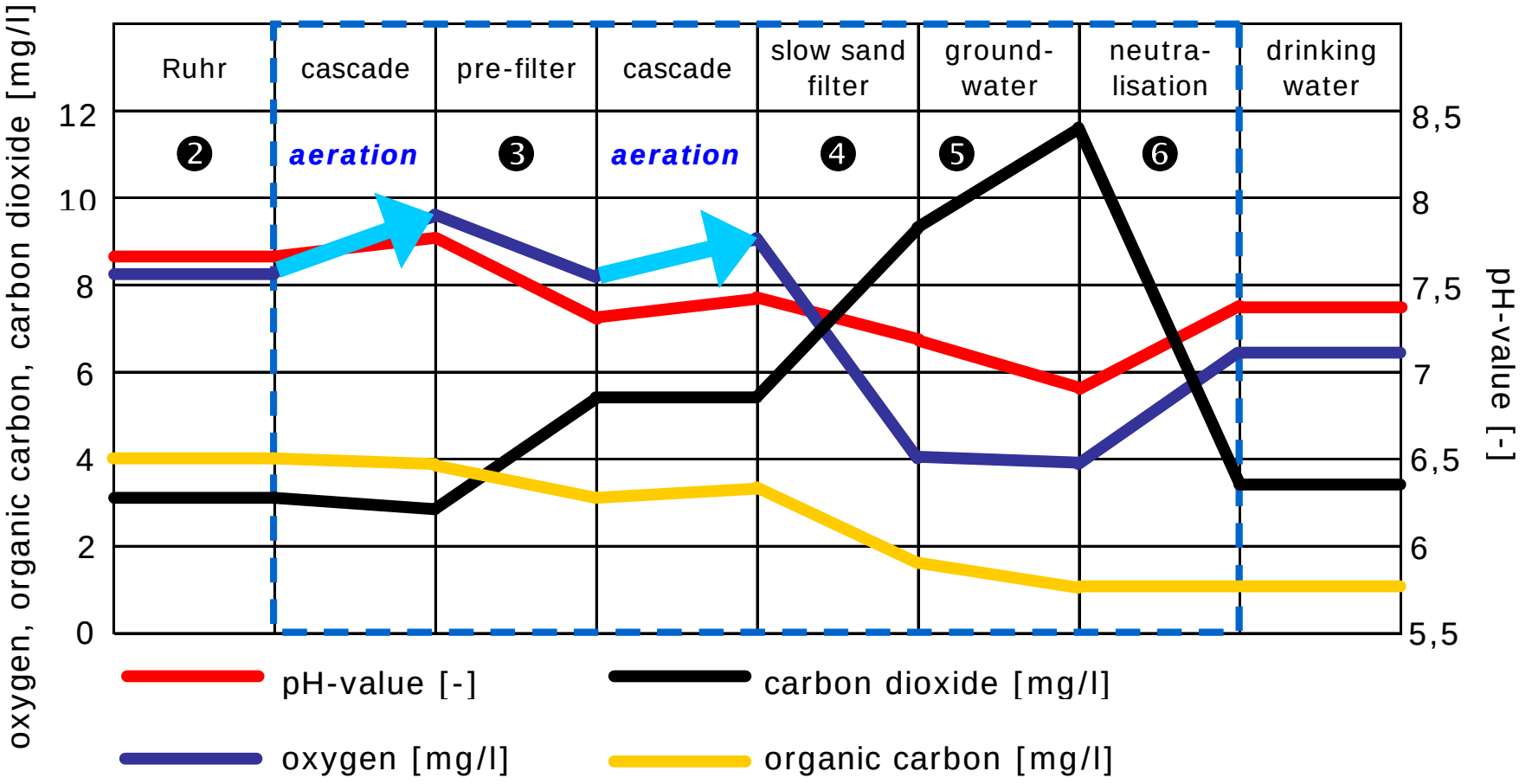
increase (CO_2, NO_3)

www.ifw-dortmund.de

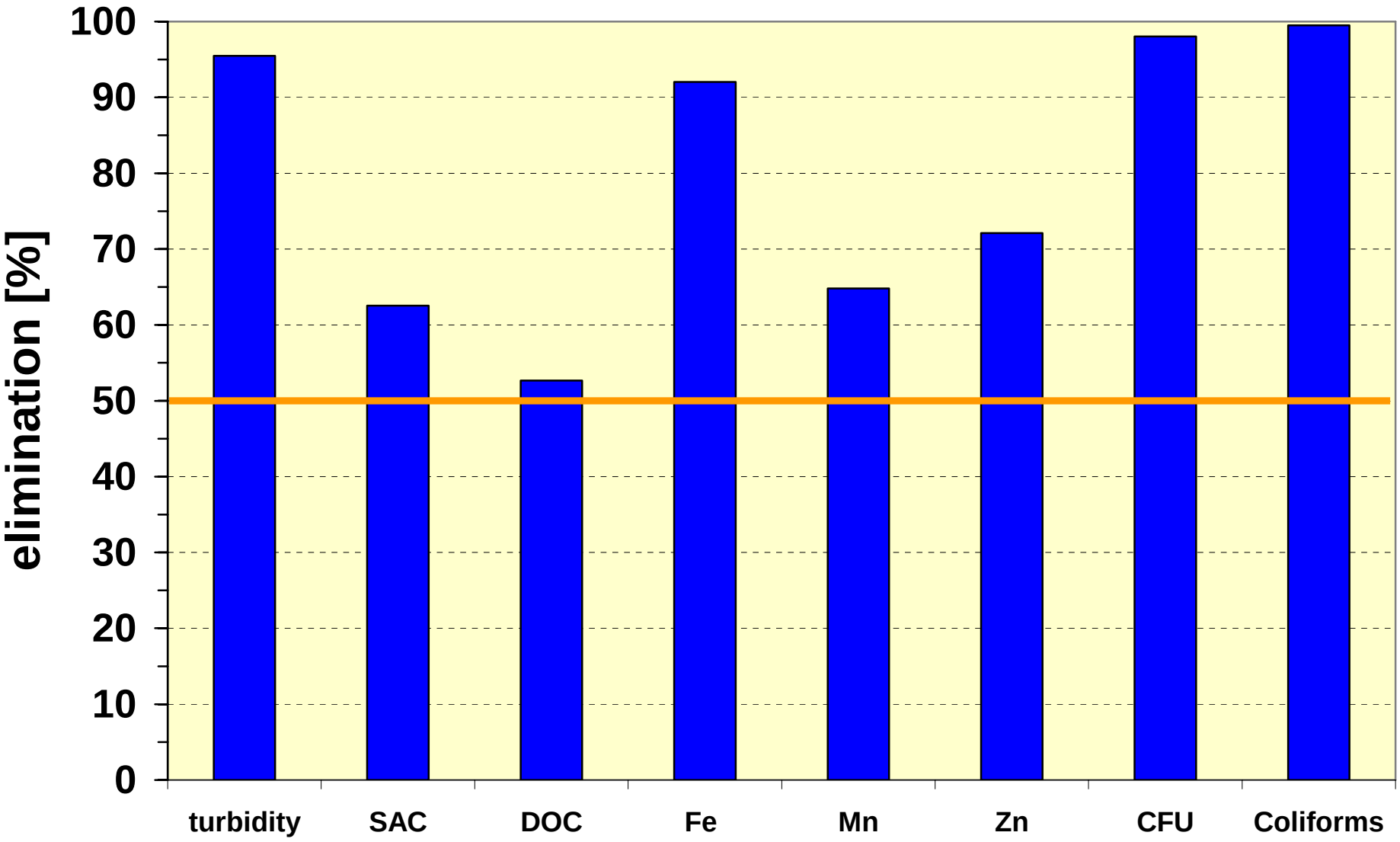
Waterworks Hengsen (Waterworks Westphalia)



Change of important parameters during artificial groundwater recharge



Removal capacity slow sand filtration and underground passage



(Mean values 10 waterworks, n= 670 - 14.600)

Remmler et al. 2004

Slow sand filtration: Removal efficiency*

Water quality parameter	Removal efficiency
Turbidity	> 90 %
Standard plate counts (CFU)	1 – 3 log units
Coliform bacteria	1 – 3 log units
E. coli	2 – 3 log units
Enteric Viruses	2 – 4 log units
Giardia cysts	2 – 4 log units
Cryptosporidium oocysts	> 4 log units
Dissolved organic carbon (DOC)	≈ 30%
Biodegradable DOC (BDOC)	< 80%

* Without underground passage

Amy et al. 2006

Trace organic compounds during slow sand filtration

Problematic substances

- soluble
- weak sorption
- not degradable under a aerobic condition

	removal	
glyphosate (polar herbicide) AMPA (metabolite)	**excellent**	Field monitoring
carbamazepine diclofenac sulfamethoxazole	**poor**	Column experiments *

* Kuhlmann et al., 2006

Summary

- near-natural treatment processes in drinking water abstraction
  - river bank filtration
  - slow sand filtration
  - high removal efficiency
- simple technology
  - cost efficiency
  - sustainability
  - resource preservation
  - energy efficiency
- modular character
  - treatment step
  - multi-barrier concept

Dziękuję państwu za uwagę !

Thank you for your attention!

skark@ifw-dortmund.de