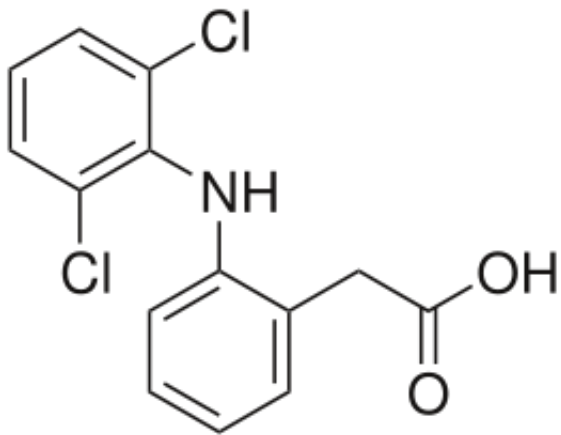


# Organic micropollutant (oMP) treatment V: pilot studies

Applied wastewater engineering

Michael Jon MATTLE



# Direct PAC-dosage into biology at WWTP Flos

- in planning/ under construction
- constructed

wastewater treatment plant Flos in Wetzikon (Canton of Zürich)

- ozone
- powdered activated carbon
- granulated or micro-grain activated carbon
- combined processes

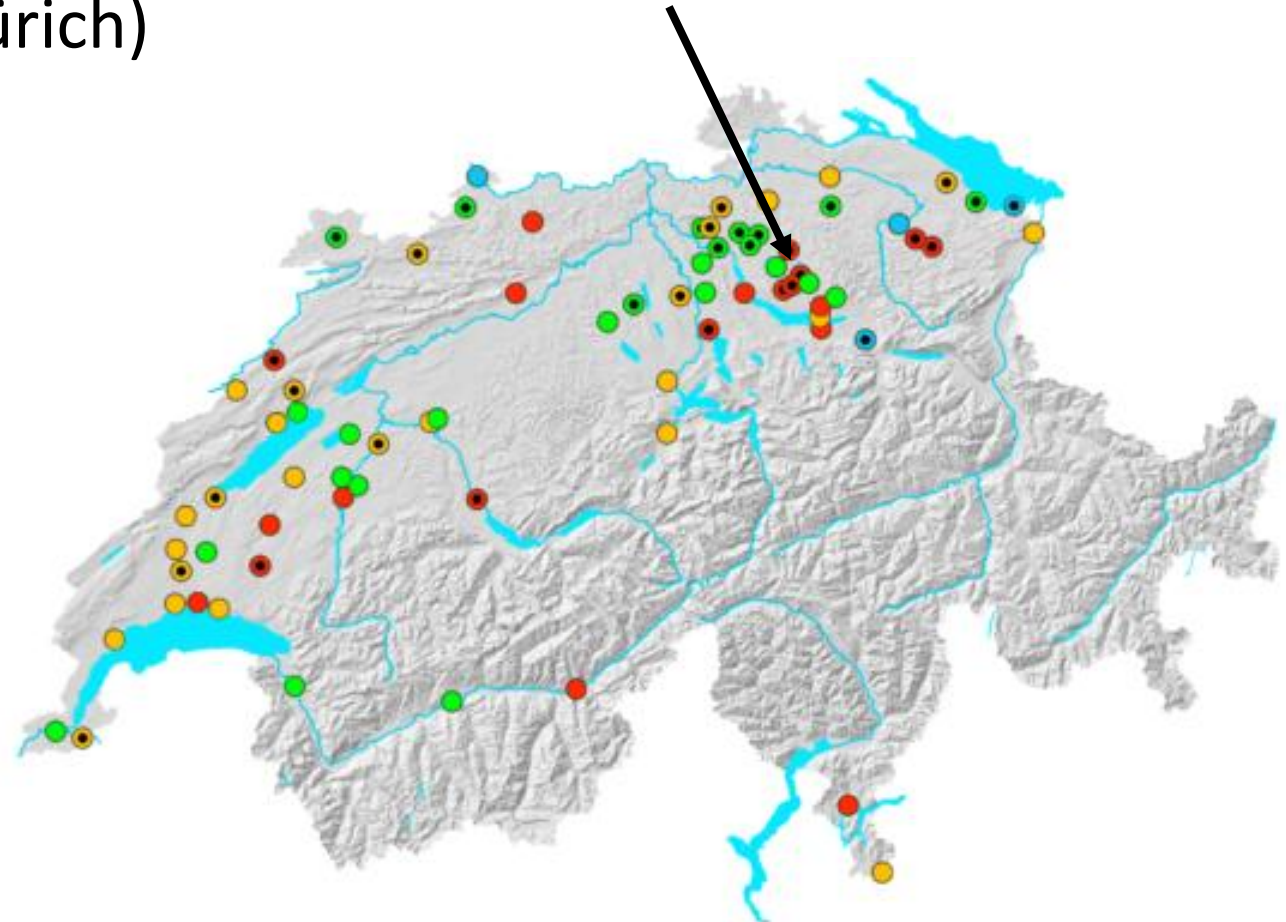
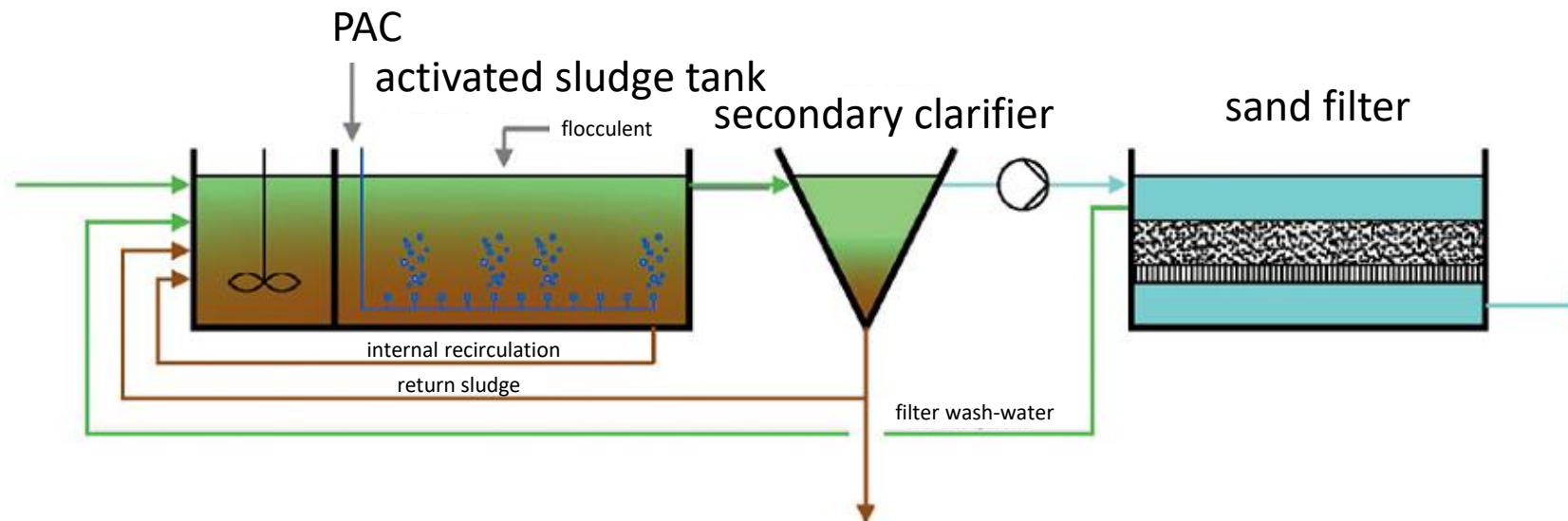


image taken from webpage: <https://www.micropoll.ch/fr>

# Direct PAC-dosage into biology

- uses existing treatment zones
  - biology serves as contact reactor
  - secondary clarifier for PAC removal from wastewater
- ➔ few modifications required to treat organic micropollutants
- sand filter serves as security to avoid PAC losses to the environment



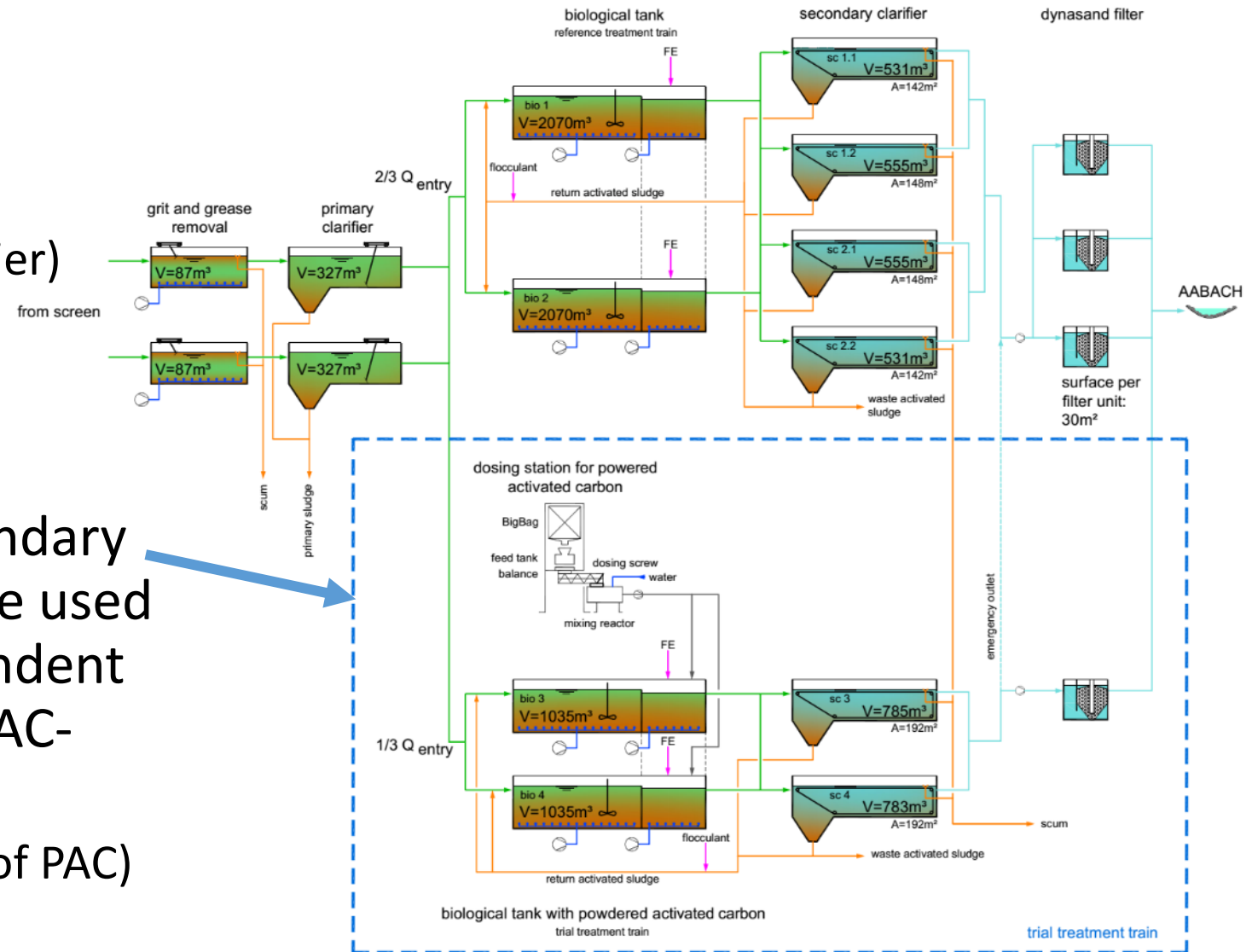
# Direct PAC-dosage into biology

- WWTP Flow in Wetzikon

- $\approx 44'000$  PE in terms of COD
- physical unit (screens, grit and grease removal, primary clarifier)
- biological tanks
- secondary clarifiers
- sand filters

- part of biological tanks, secondary clarifiers and sand filters were used for trials (completely independent of rest of treatment plant): PAC-dosage into biology

- reference biology (no dosage of PAC)



# Some impressions (WWTP Flos, Wetzikon)



PAC was delivered in big-bags

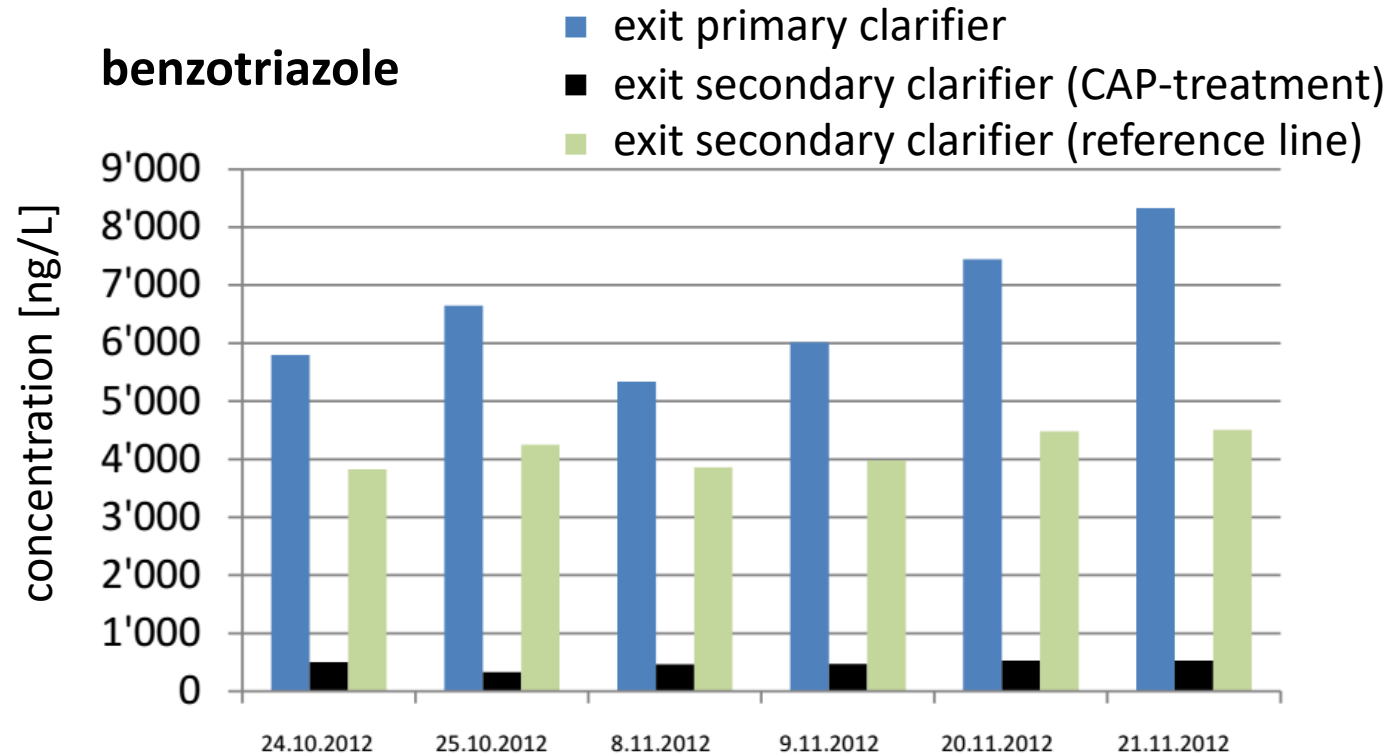
WWTP Flos  
in Wetzikon



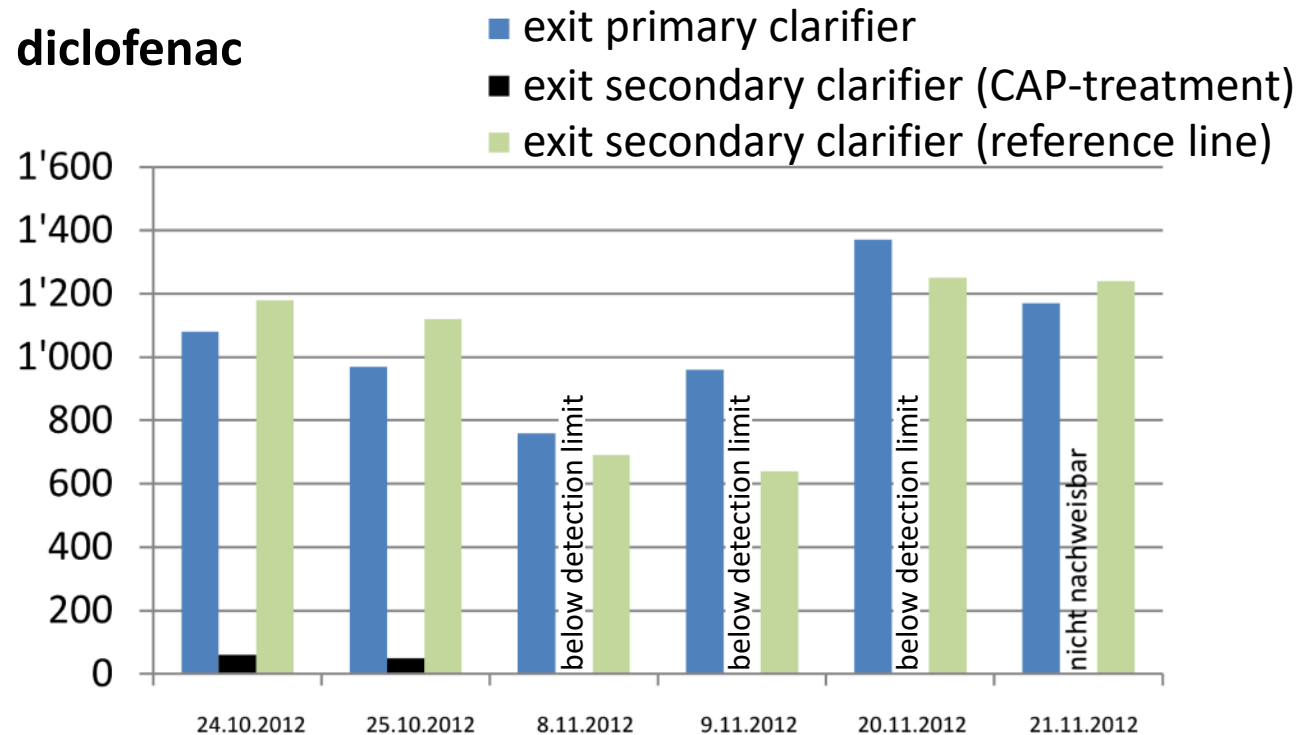
PAC dosage  
directly into  
biological tank

# Results from trial experiments (large scale)

- influent concentration of benzotriazole is in the range of several  $\mu\text{g}/\text{L}$  (present in dishwashing detergents)
- a fraction of benzotriazole is removed in the biological treatment
- dosage of activated carbon reduced the effluent concentration of benzotriazole substantially



# Results from trial experiments (large scale)



- initially diclofenac is below benzotriazole concentration
- biological treatment has little effect on diclofenac concentrations
  - sometimes positive results are measured → due to variations in the influent concentration
- addition of activated carbon is very efficient for diclofenac removal
- effluent concentration of diclofenac is often below detection limit
  - hence, exact removal cannot be determined but only > ... % removal

# Summary of trials at WWTP Flos

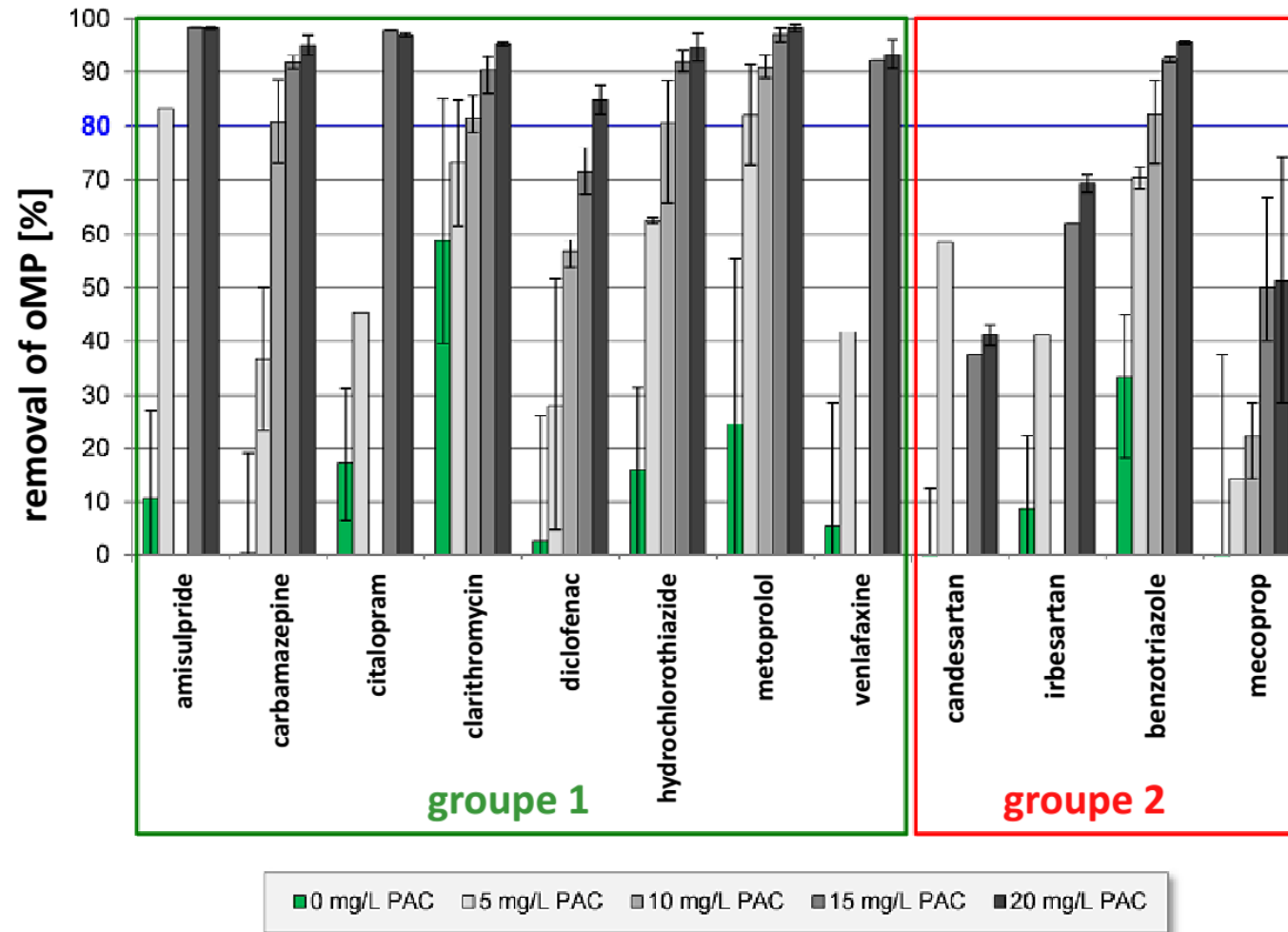
- 18 mg/L PAC ( $\approx 2 \text{ gPAC/gDOC}_{\text{sec. clarified wastewater}}$ ) achieved more than 80 % elimination of studied organic micropollutants (except mecoprop which could not be detected)
- 11 mg/L PAC ( $\approx 1 \text{ gPAC/gDOC}_{\text{sec. clarified wastewater}}$ ) could not achieve 80 % removal for more than half of the organic micropollutants studied

Trial	CAP concentration	benzotriazole	carbamazepine	diclofenac	mecoprop	methylbenzotriazole	(methyl)sulfamethoxazole	clarithromycin
unit	[mg/L]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
1	18	93	88	95	-	98	94	84
2	18	92	84	98	-	97	94	71
3	18	93	92	98	-	98	97	90
4	11	81	73	61	43	91	83	60

# Direct PAC-dosage into biology

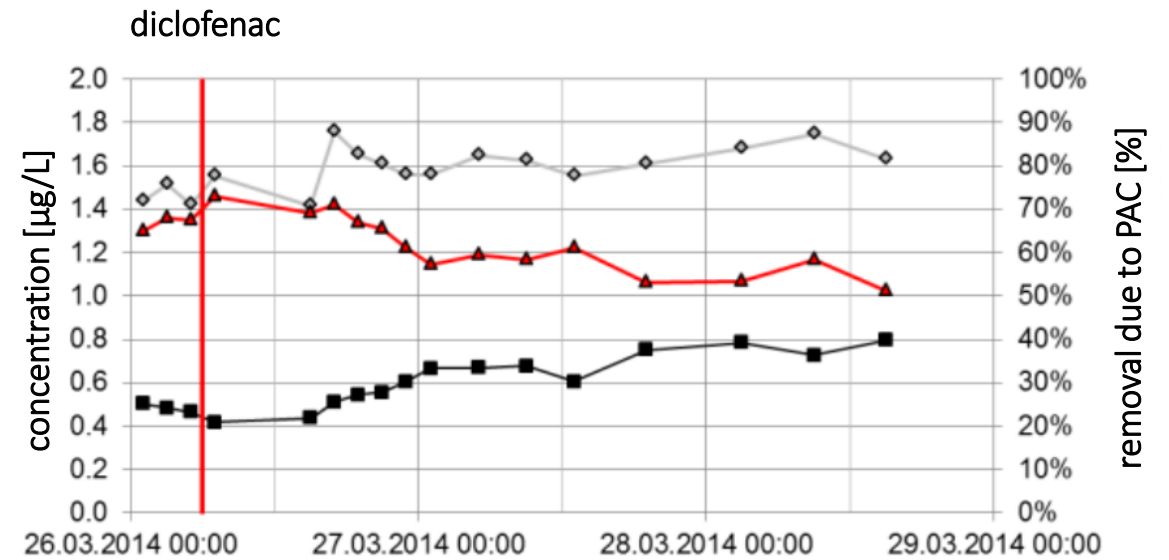
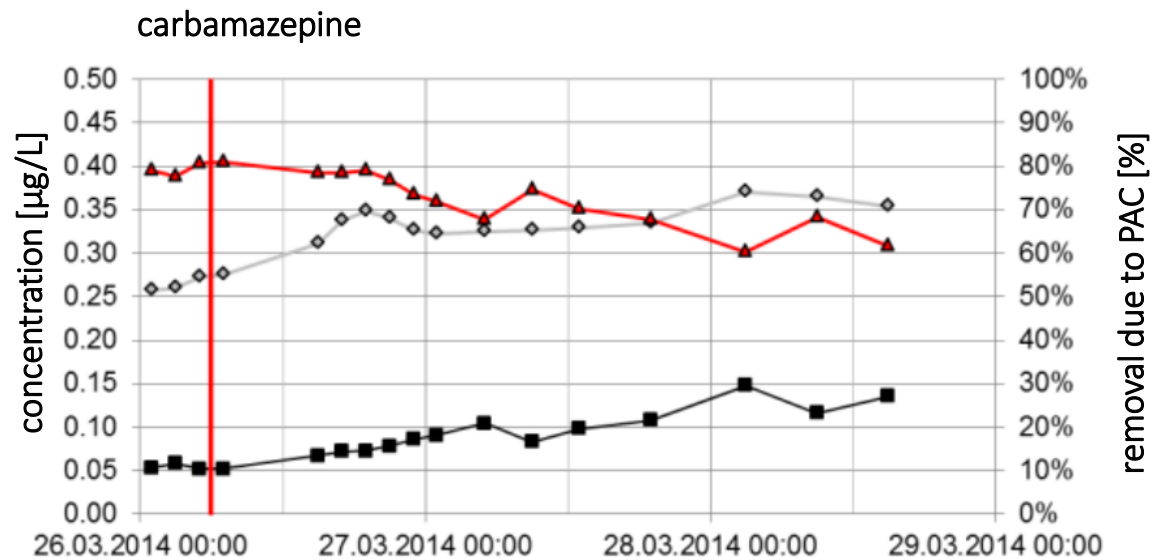
- results from similar trials at wastewater treatment plant Schönau, ZG
- diclofenac (group 1) is more difficult to remove than benzotriazole (group 2)
- choice of substances has an important impact on dosage requirements

**→**  $\approx 15 \text{ mg/L PAC}$   
( $\approx 2 \text{ gPAC/gCOD}_{\text{sec. clarified wastewater}}$ ) are required to achieve 80 % removal



# Direct PAC-dosage into biology (dosage stop)

- even without dosage of PAC, removal of organic micropollutants continues
- system is rather robust (important removal without PAC dosage)
- dosage of new PAC required to achieve 80 % removal

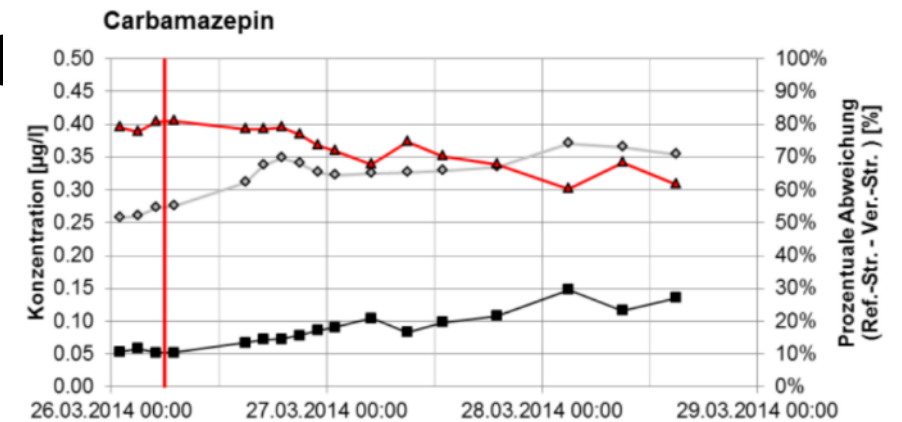


exit sand filters (trial zone); exit sand filters (reference); elimination due to PAC (%)

# Dosage stop (direct PAC-dosage into biology )

Why do you think that the removal of oMP continues even though no additional PAC is added?

- A) it is mainly because of biological removal
- B) it must be due to an analytical error
- C) as the concentrations of oMP increase in the wastewater, PAC is capable to adsorb more micropollutants
- D) the PAC has more time to adsorb oMP because it is kept longer in the system



<https://web.speakup.info/room/join/50744>

# Direct PAC-dosage into biology

- direct PAC dosage into the biological tank is a feasible option for organic micropollutant removal
  - no additional contact reactor is required
  - no additional separation (PAC-removal from wastewater) has to be built
  - the process is robust and even at a stop of PAC dosage an important fraction of organic micropollutants are still removed
  - higher PAC quantity is required to treat the same amount of wastewater (as compared to the Ulm-process)
  - more sludge is produced due to higher PAC dosage → slight reduction of biological treatment capacity
  - trials indicate that a sand filter is required for complete PAC removal from wastewater

 definitively implanted at WWTP Flos in Wetzikon

# Fluidised activated carbon bed

- in planning/ under construction
- constructed

wastewater treatment plant Penthaz  
(Canton of Vaud)

- ozone
- powdered activated carbon
- granulated or micro-grain activated carbon
- combined processes

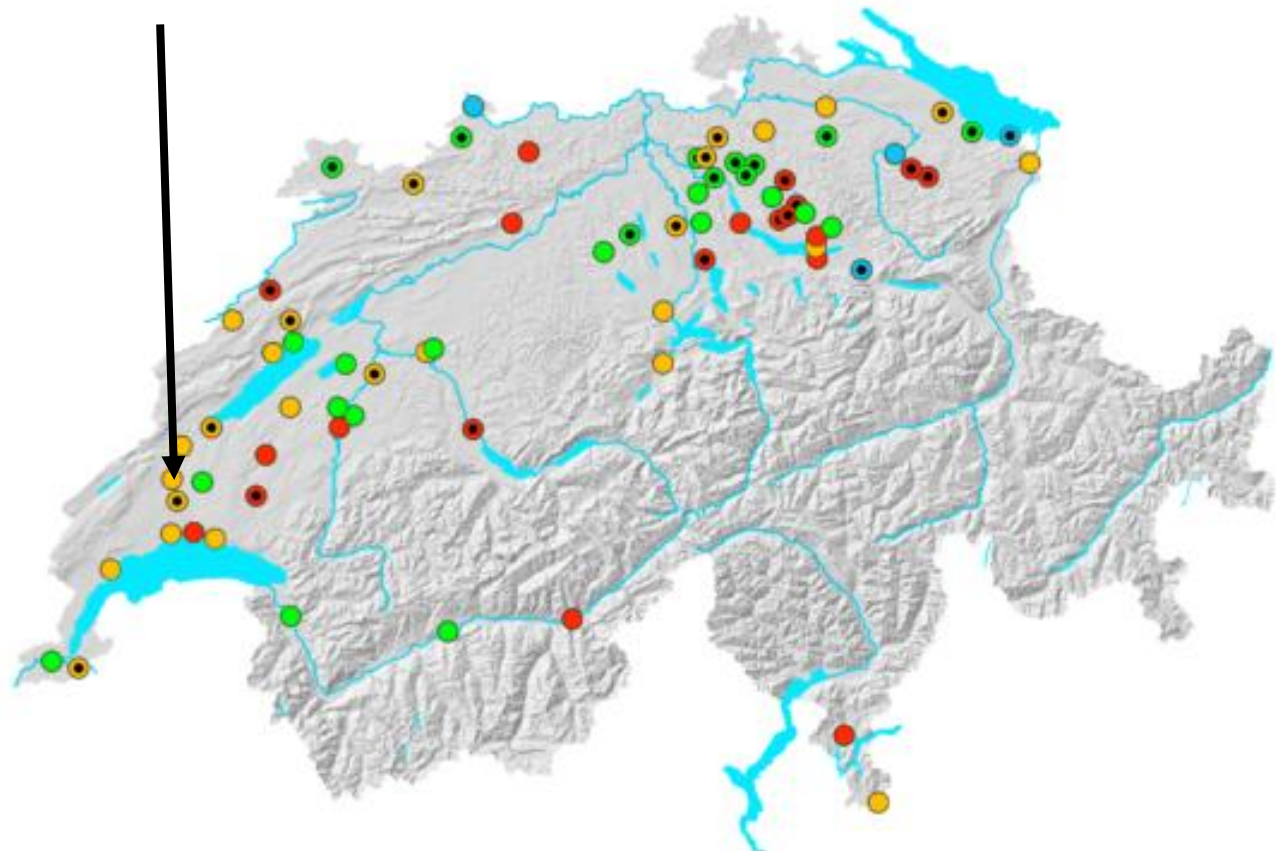
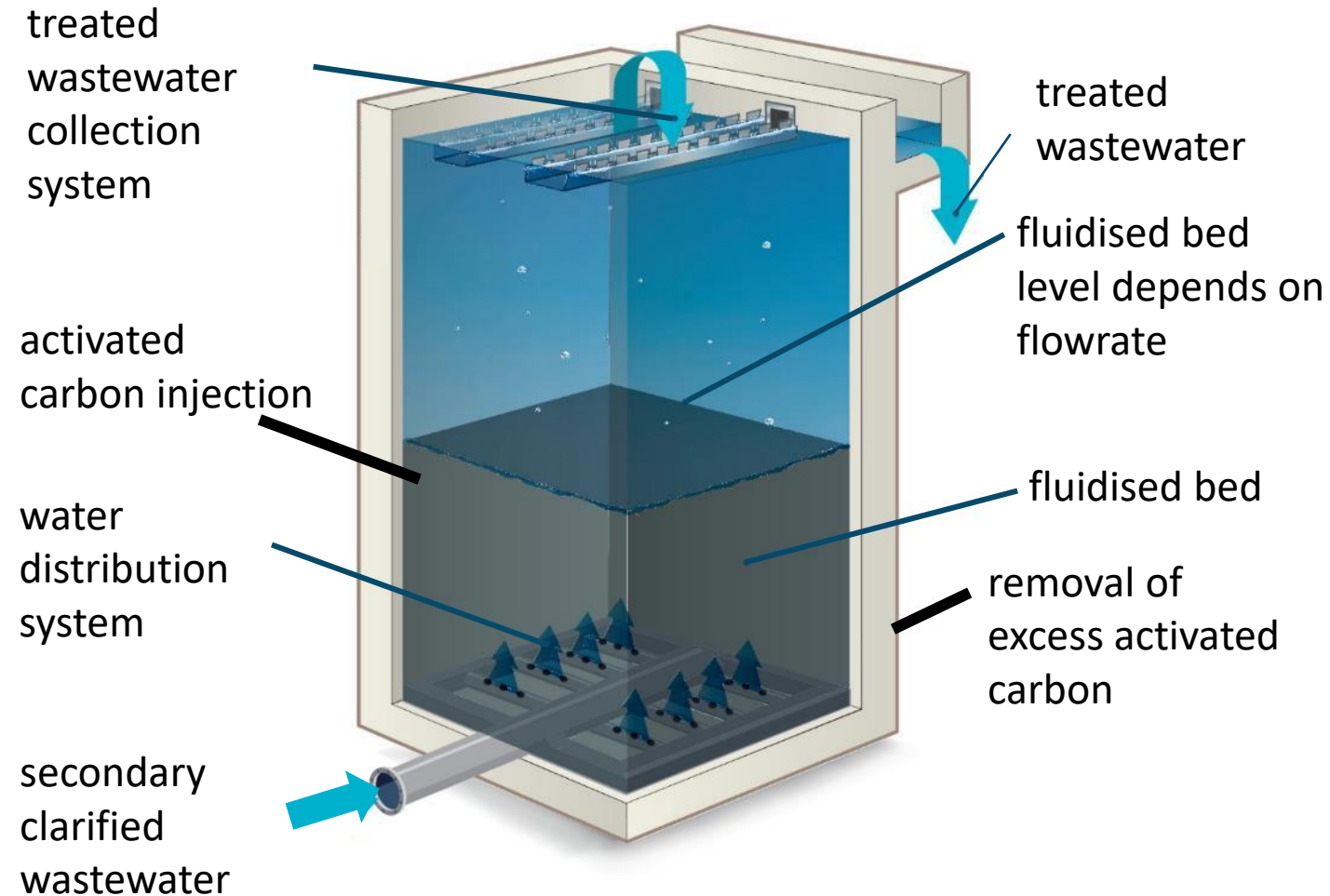


image taken from webpage: <https://www.micropoll.ch/fr>

# Activated carbon in fluidised bed

## activated carbon in fluidised bed

- micro-grain activated carbon is kept in suspension by upflow of wastewater
- patented process
- reactor requires little space as 'filtration' and separation is in the same unit
- sand filtration was not required by Canton/FOEN for the installation at the WWTP of Penthaz



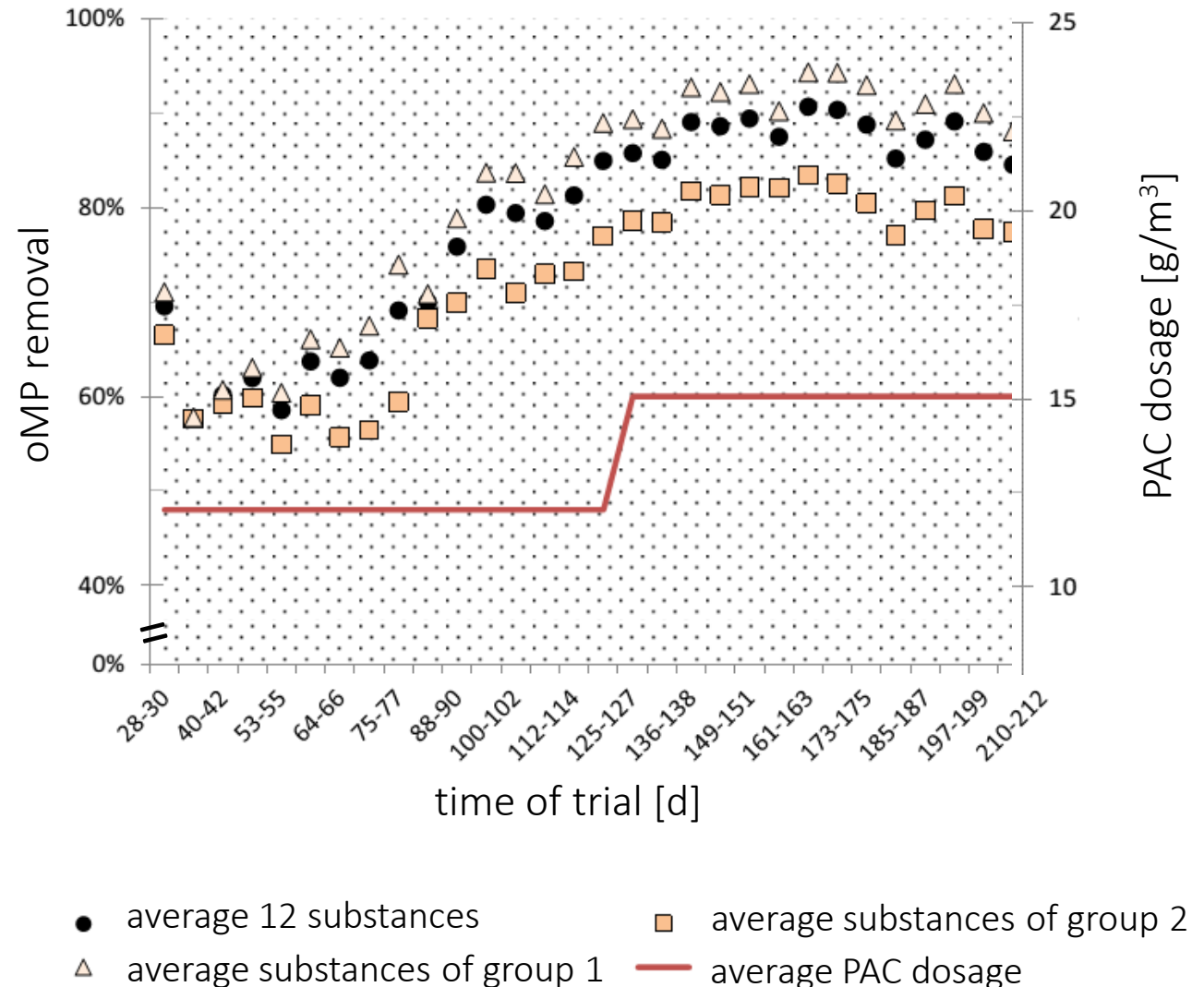
# Activated carbon in fluidised bed

- WWTP Penthaz
  - designed for 15'000 PE
  - currently treating wastewater of  $\approx 9'500$  people
  - physical unit (screens, grit and grease removal, primary clarifier)
  - biological tanks (C, N and P)
  - secondary clarifiers
  - disk filters
- 15 m<sup>3</sup>/h were diverted towards the pilot plant



# Activated carbon in fluidised bed

- 15 mg PAC/L ( $\approx 2.0 \text{ g } \mu\text{GAC/g COD}_{\text{sec. clarified wastewater}}$ ) achieved 80 % removal of oMP (by  $\mu\text{GAC}$  treatment only)
- stable removal of oMP required time (AC sludge age  $\approx 90$  days)
- fine fraction of  $\mu\text{GAC}$  has to be removed before entering the system to avoid losses of  $\mu\text{GAC}$



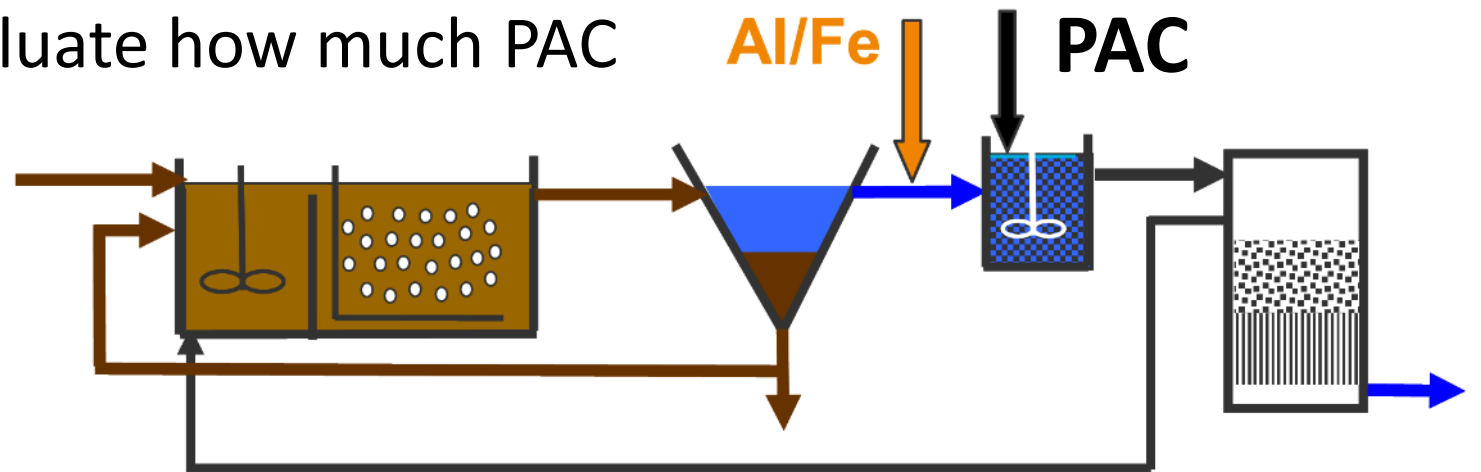
# Some impressions (pilot tests at WWTP Penthaz)

- column used to conduct trials; containing about 60 kg of  $\mu$ GAC



# Other AC processes not discussed in detail

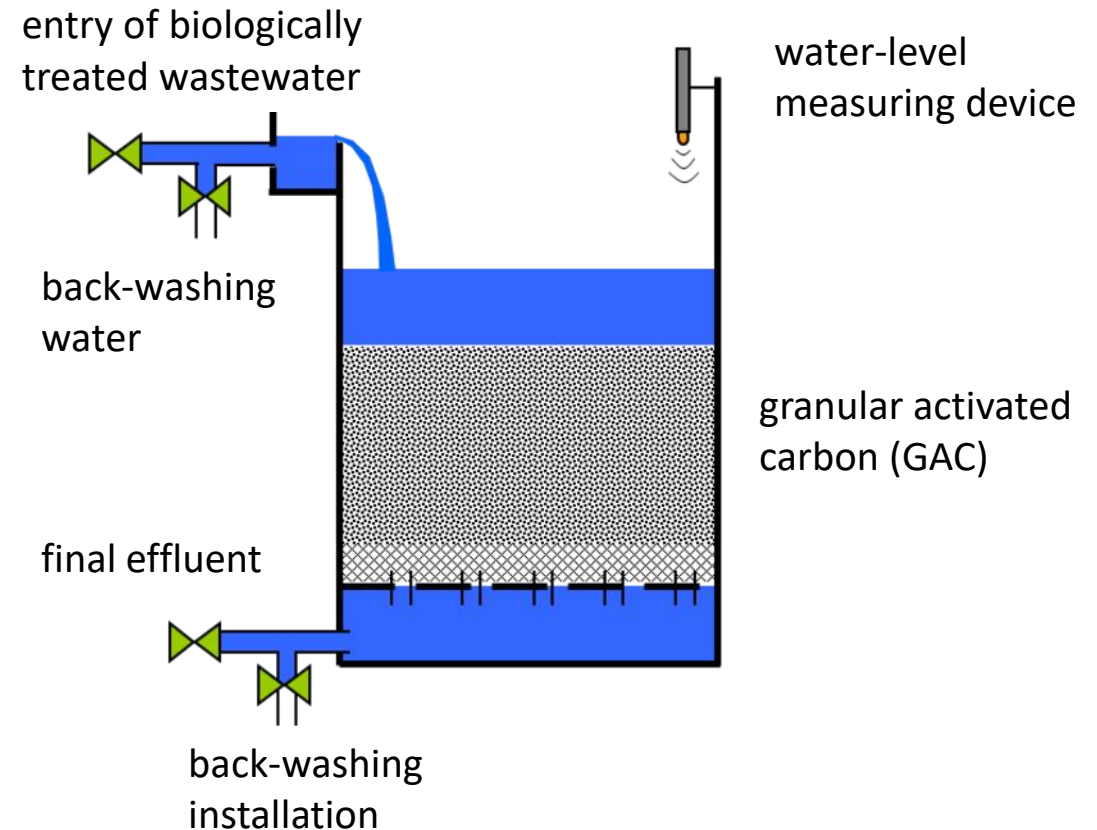
- addition of powdered activated carbon into coagulation/flocculation tank (stirred)
- removal of PAC directly by rapid sand filtration
  - first tested at Eawag
  - large-scale testing at WWTP Ergolz, Sissach
- process requiring little space
- relatively difficult to evaluate how much PAC leaves the sand filter (detection limit)



# Other AC processes not discussed in detail

## granulated activated carbon

- operation similar to a sand filter but additionally removes oMP
- adsorption and filtration occurs in one step (sand filtration not required)
- highest saturation of activated carbon obtained if different filter units are operated at different saturation rates
  - most saturated GAC is regenerated once required
- relatively difficult to optimise between 80 % removal yield and maximum saturation of activated carbon



# Characteristics of different types of activated carbon

criteria	powered activated carbon (PAC)	granular activated carbon (GAC)	micro-grain activated carbon ( $\mu$ CAG)
difficulty to put into water	rather complicated	rather easy	rather easy
difficulty to remove from water	rather complicated	easy	rather easy
filtration	construction required	yes	partial
recirculation of AC into biology (activated sludge process)	possible	no	potentially possible $\rightarrow$ rendering regeneration impossible
experience from large scale plants	many	still few for wastewater treatment	still few for wastewater treatment
activated carbon sellers	many	many	few

# Summary of tests conducted in Switzerland

- many other trials have been conducted in Switzerland
  - a lot of practical knowledge generated over a short period of time
  - strongly pushed by the Federal office for the environment (FOEN)
  - permitted the construction and planning of several oMP treatment units
- for further information consult:
  - [micropoll.ch](http://micropoll.ch)

- in planning/ under construction
- constructed

