Evaluation of Trickle-Bed Air Biofilter Performance for Removal of Paint Booth VOCs under Stressed Operating Conditions

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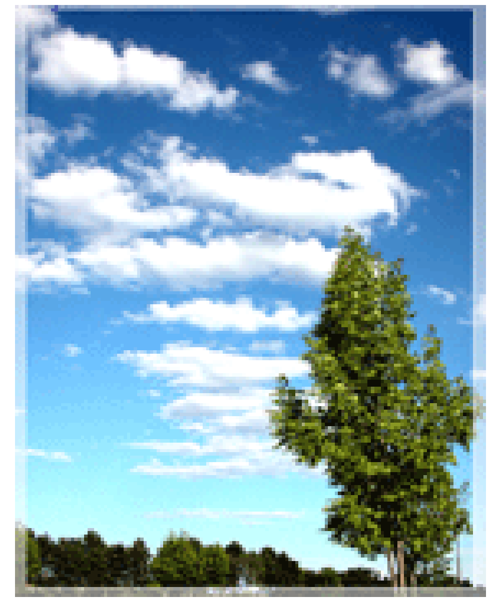
Indianapolis, Indiana,
June 24, 2004



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Evaluation of Trickle-Bed Air Biofilter Performance for Removal of Paint Booth VOCs under Stressed Operating Conditions

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Background

Source: http://www.aecon.net/Siko.html

Paint Booth Emission

- Intermittent operation
- Variable and unsteady VOC loading
- Complex mixtures of VOC
  Hydrophobic / Hydrophilic compounds, or
  Biodegradable / Recalcitrant compounds

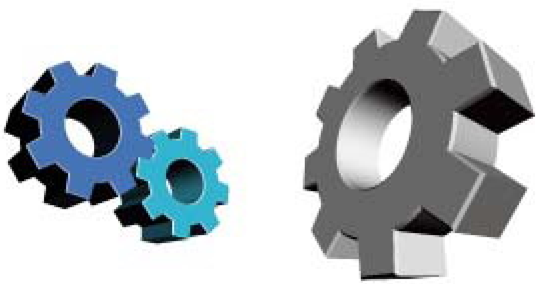
Source: http://www.eastwayrefurb.com

Evaluation of Trickle-Bed Air Biofilter Performance for Removal of Paint Booth VOCs under Stressed Operating Conditions

Background

Paint Booth VOC Control Technology

- Requirement
  - ✓ Environmental friendly
  - ✓ Economical viable
  - ✓ Consistent high performance



Biofiltration !!

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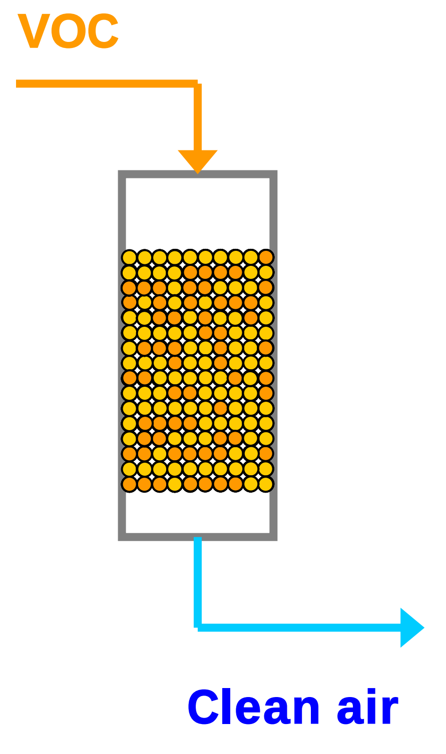
Background

Biofiltration

: Typical biological air treatment process

- VOCs are removed through a biologically active media
- Natural organic media (soil, compost)
  → easily exhaust nutrient & buffer capacity
  → long term operation is impractical



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Background

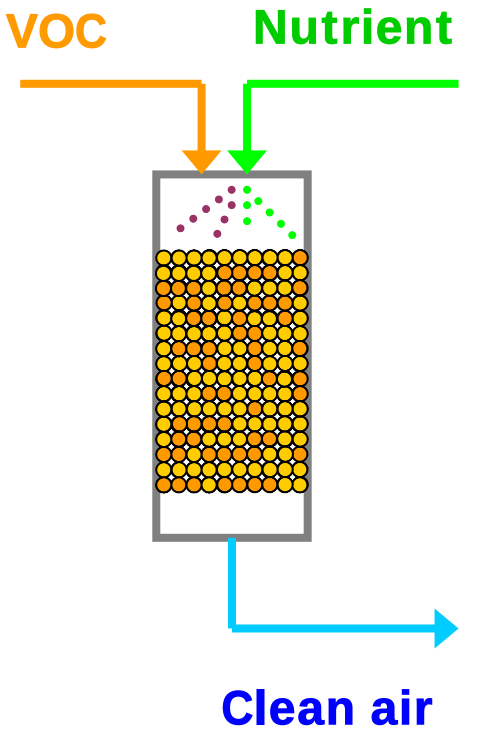
Trickle-Bed Air Biofilter (TBAB)

: identical process to the biofilter

- Nutrient and pH control
- Synthetic & inorganic media

→ Optimizing the contaminant utilizing kinetics for microorganisms

→ Long term, high removal performance



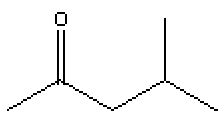
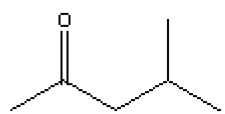
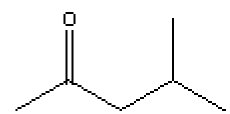
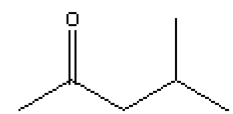
objective

To investigate the performance of a TBAB under periodic stressed operating conditions (*backwashing & non-use periods*) as a function of Paint booth VOC loading.

- Removal characteristics of VOC in TBAB
- Comparison of TBAB performance

Experimental Methods

Target VOCs

	Hydrophobic compounds		Hydrophilic compounds	
	Toluene	**Styrene**	**Methyl ethyl ketone** (MEK)	**Methyl isobutyl ketone** (MIBK)
				
K'_H	0.280	0.109	0.00194	0.00062
Log K_{ow}	2.58	3.16	0.28	1.09

K'_H = dimensionless Henry's law constant, *K_{ow} = Octanol-water partition coefficient*

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Experimental Methods

Reactor : Independent lab-scale TBAB

Media: pelletized biological support media

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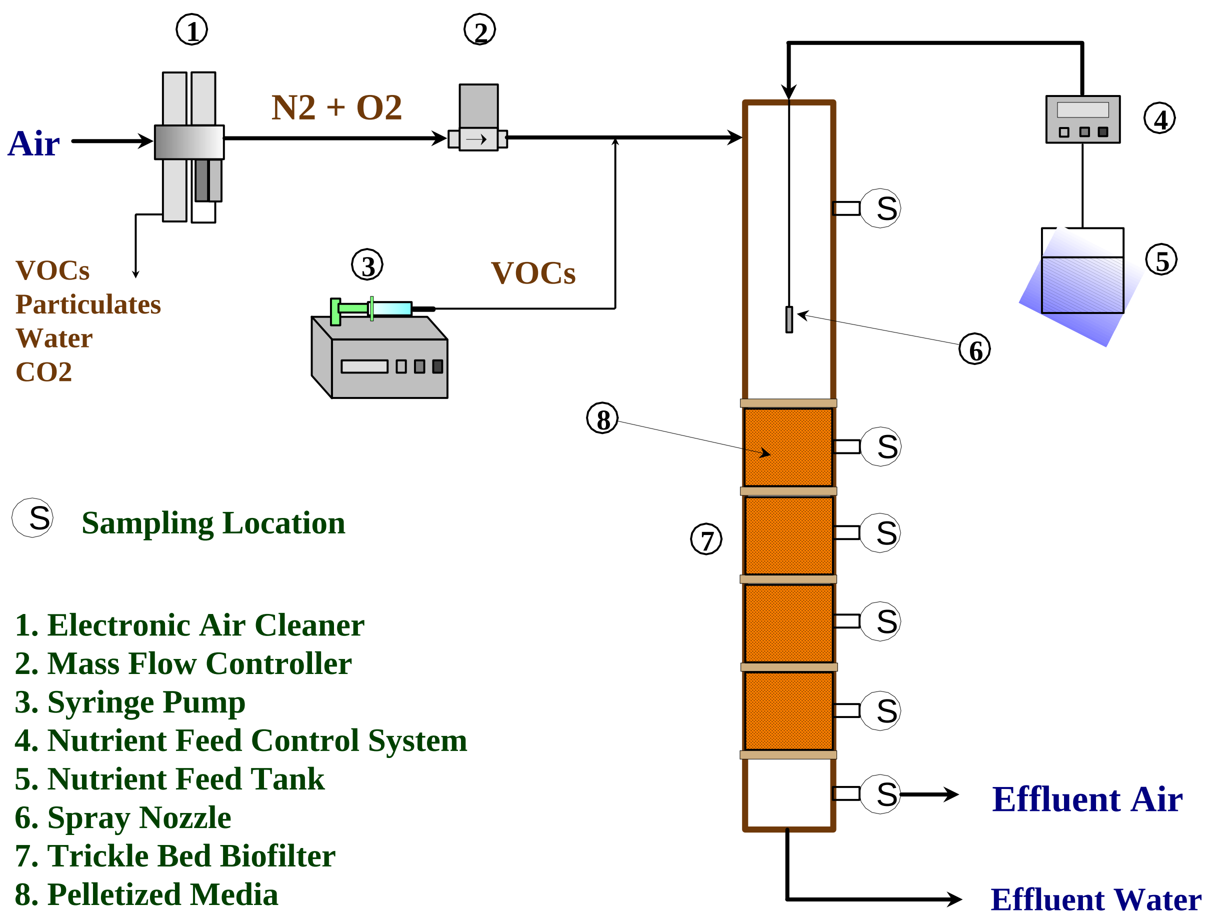
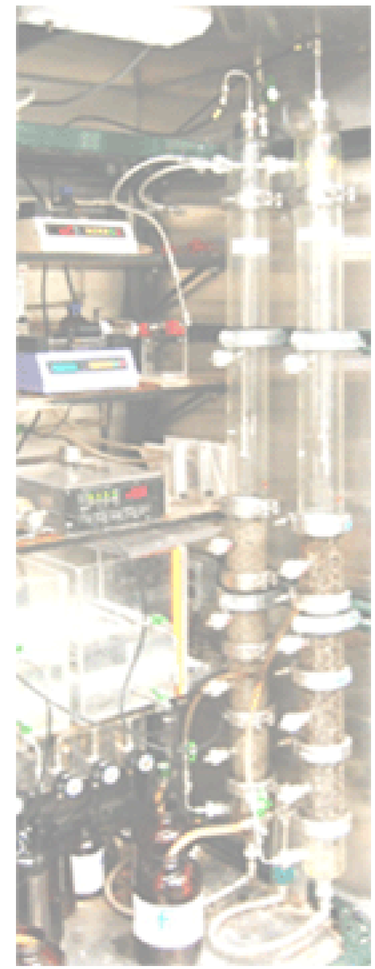


1. Electronic Air Cleaner
2. Mass Flow Controller
3. Syringe Pump
4. Nutrient Feed Control System
5. Nutrient Feed Tank
6. Spray Nozzle
7. Trickle Bed Biofilter
8. Pelletized Media



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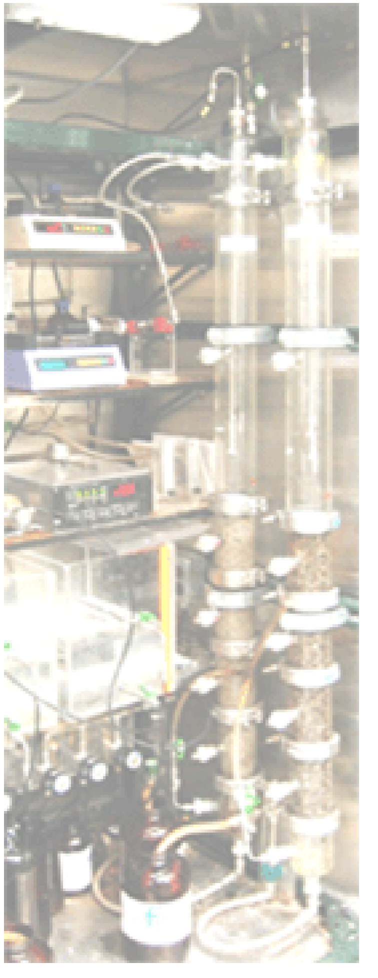
Experimental Methods

Stressed operating conditions

- **Backwashing**
- **Non-use periods**
  - ✓ Starvation
  - ✓ Stagnant



Experimental Methods

Backwashing

- Biomass control for long-term high removal performance
- Periodic in-situ upflow fluidization
- Using nutrient solution
- Frequency: 1 hour per week

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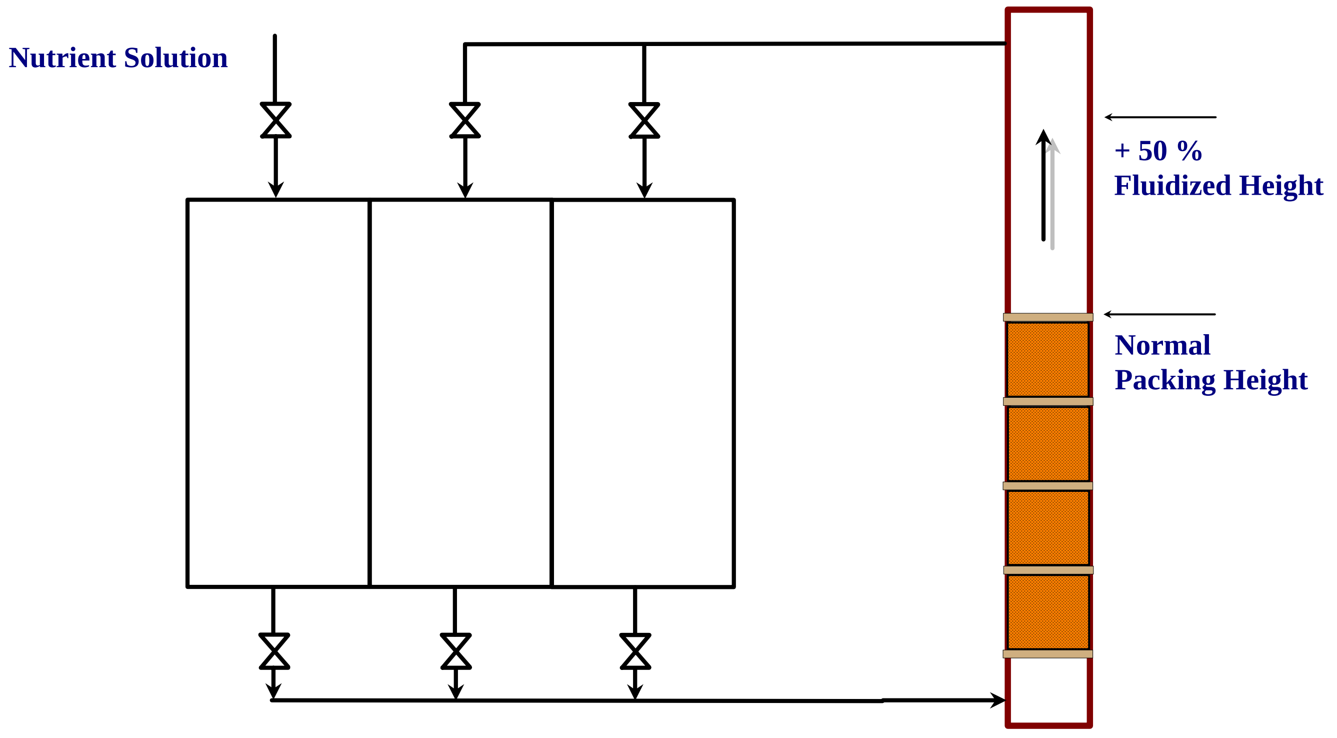
Experimental Methods

Backwashing



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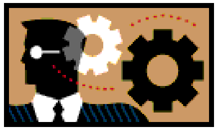
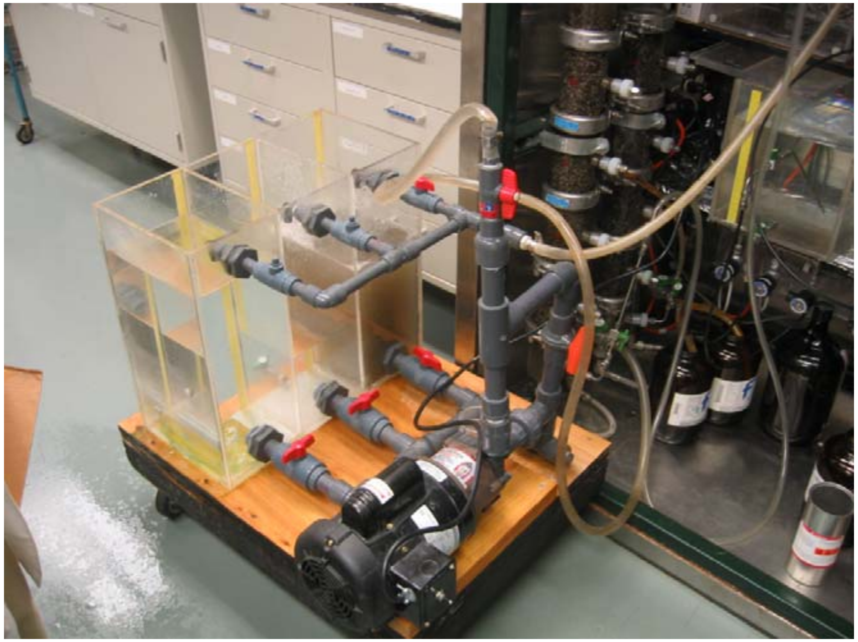
Experimental Methods

Backwashing





Experimental Methods

Non-use period

- Simulation of intermittent operation
  (shut down for weekend and holiday, or for repair)
  - ✓ Starvation: no VOC loading,
    Only pure air with nutrient passing through the biofilter
  - ✓ Stagnant: no flows (VOC, nutrient, air)
- Frequency: 2 days shut down / week
- without backwashing as biomass control

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Results

- Removal capacity for single VOC
- Removal reaction kinetics for single VOC
- Biofilter response after stressed operating conditions

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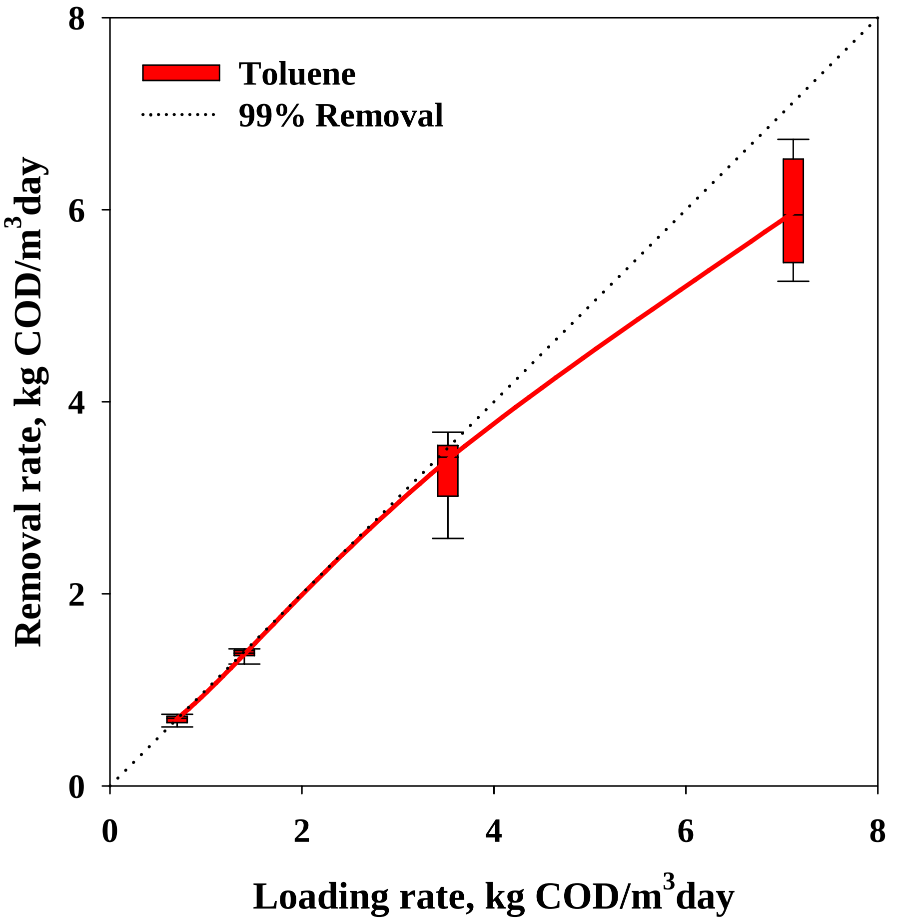
Results: Removal capacity

Aromatic compounds

Toluene

- Critical loading
  3.5 kg COD/m³·day
- Maximum removal capacity
  6.0 kg COD/m³·day



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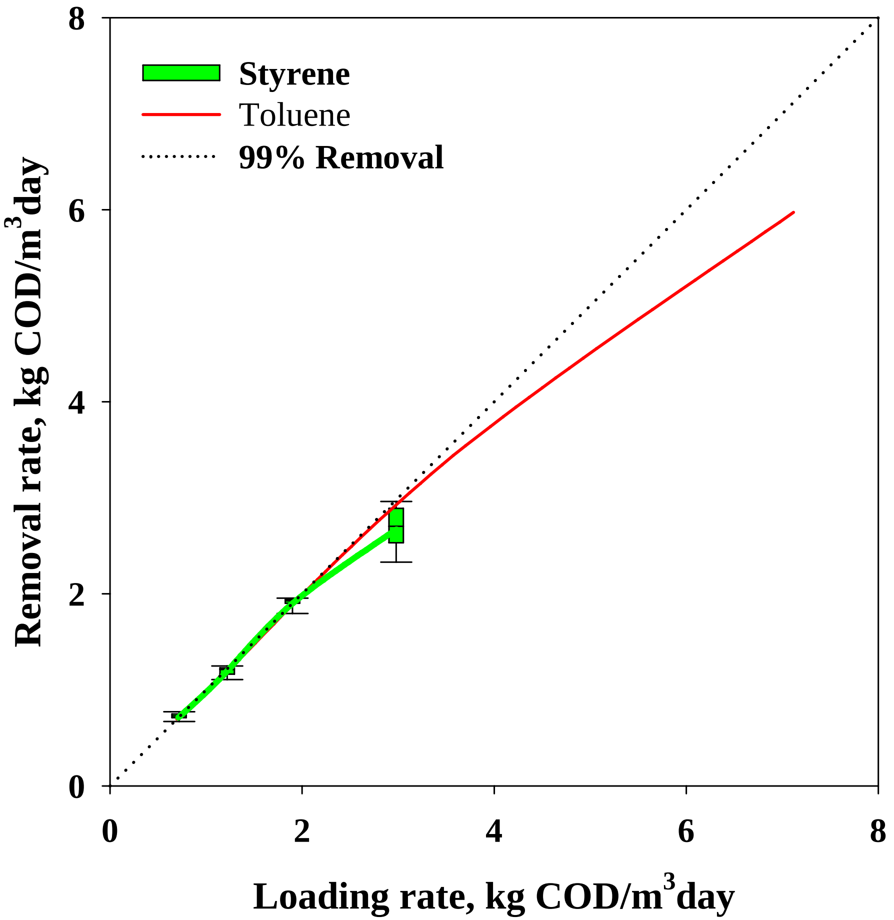
Results: Removal capacity

Aromatic compounds

Styrene

- Critical loading
  1.9 kg COD/m³·day
- Maximum removal capacity
  2.7 kg COD/m³·day



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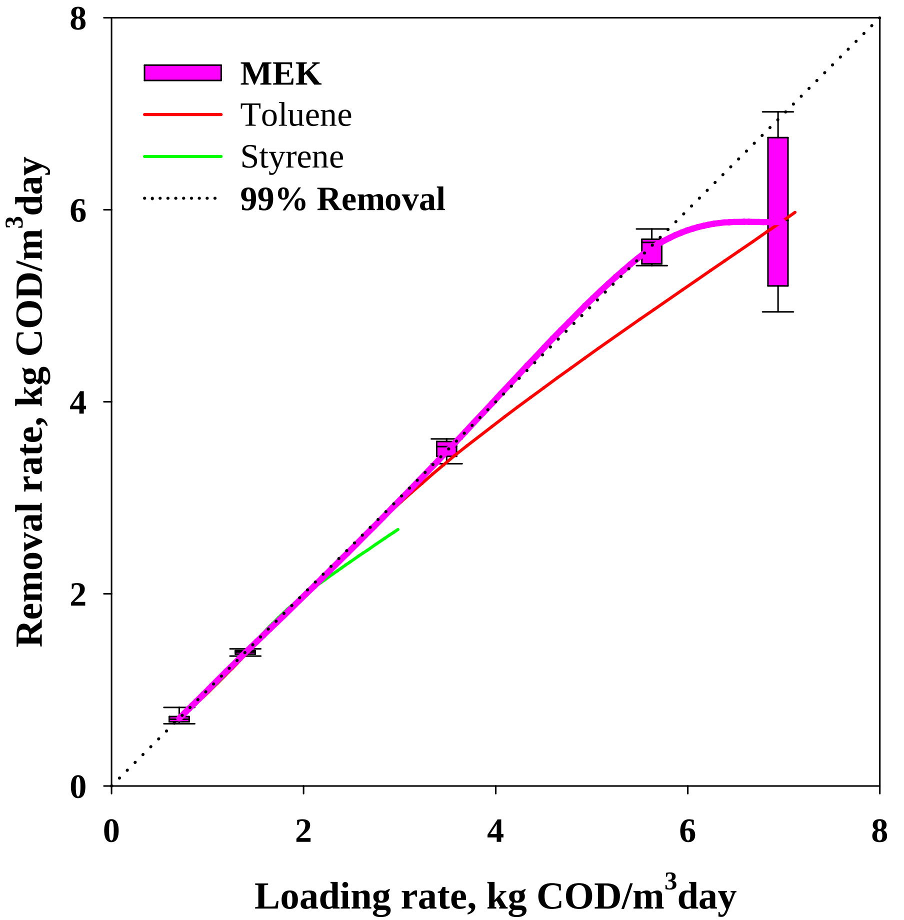
Results: Removal capacity

Oxygenated compounds

MEK

- Critical loading
  5.6 kg COD/m³·day
- Maximum removal capacity
  5.9 kg COD/m³·day



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Results: Removal capacity

Oxygenated compounds

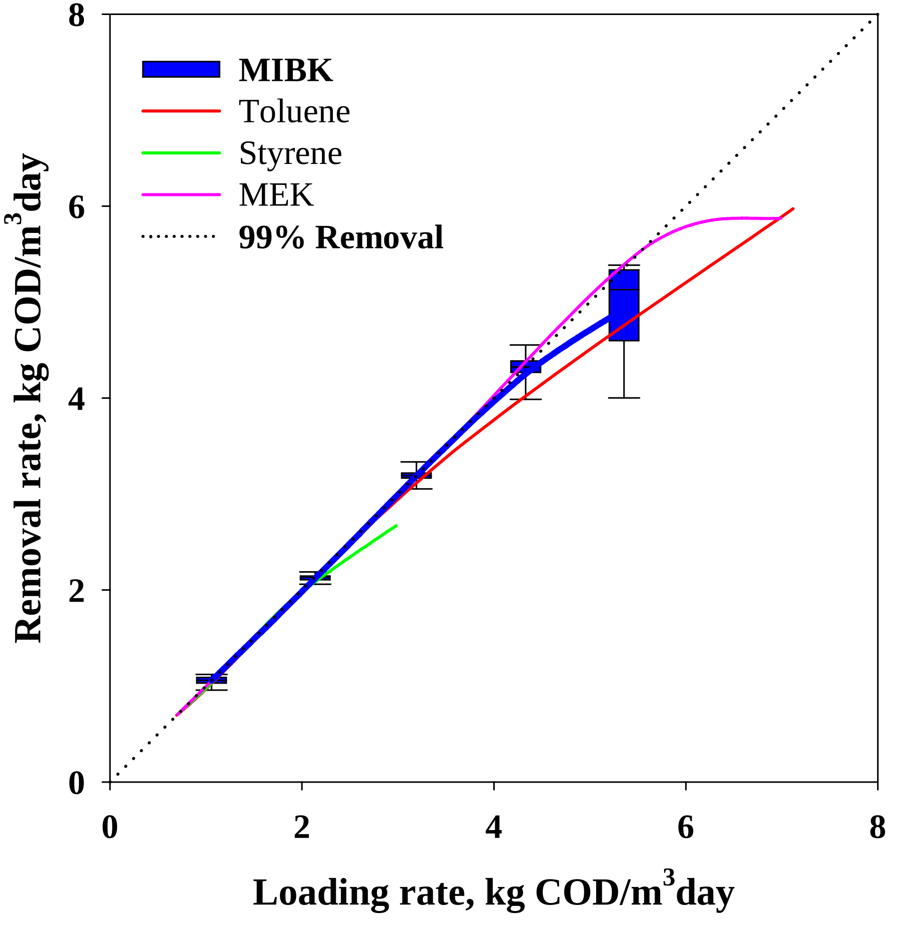
MIBK

- Critical loading

  4.3 kg COD/m³·day

- Maximum removal capacity

  4.9 kg COD/m³·day



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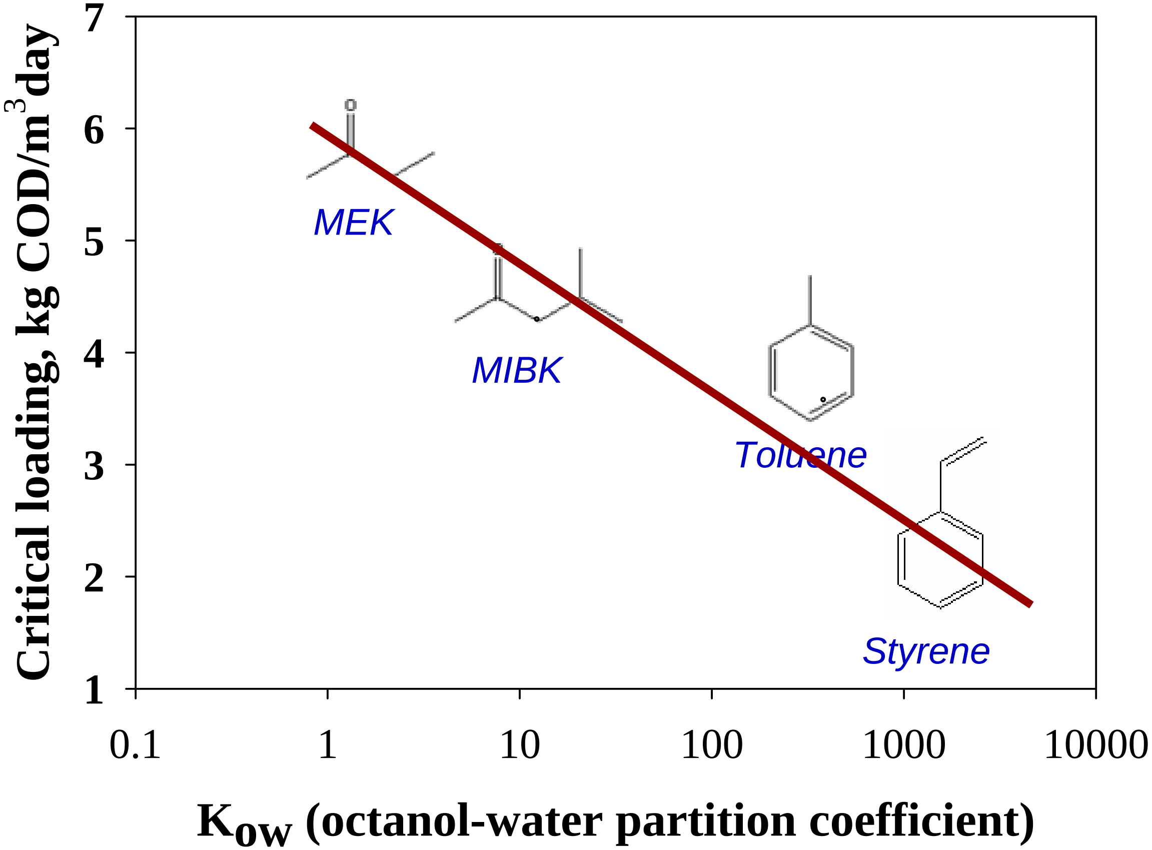
Results: Critical loading vs. K_{ow}



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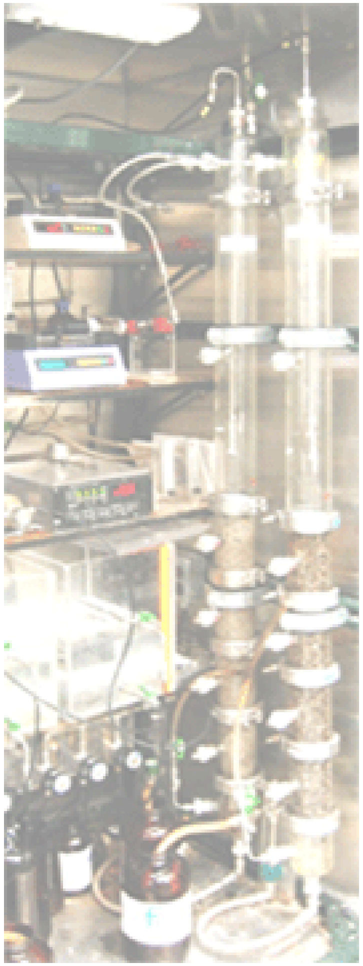
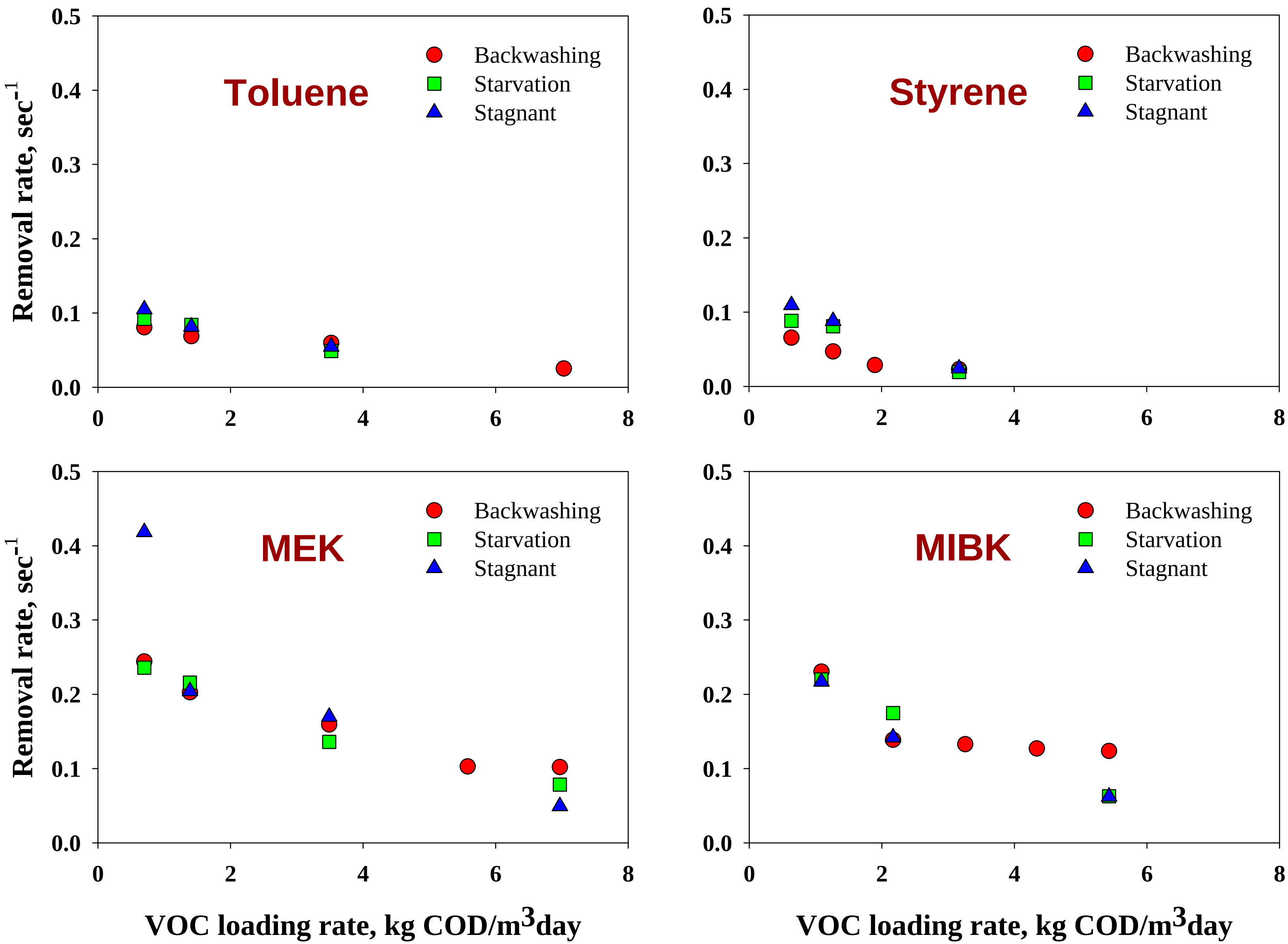
Results

Kinetic analysis

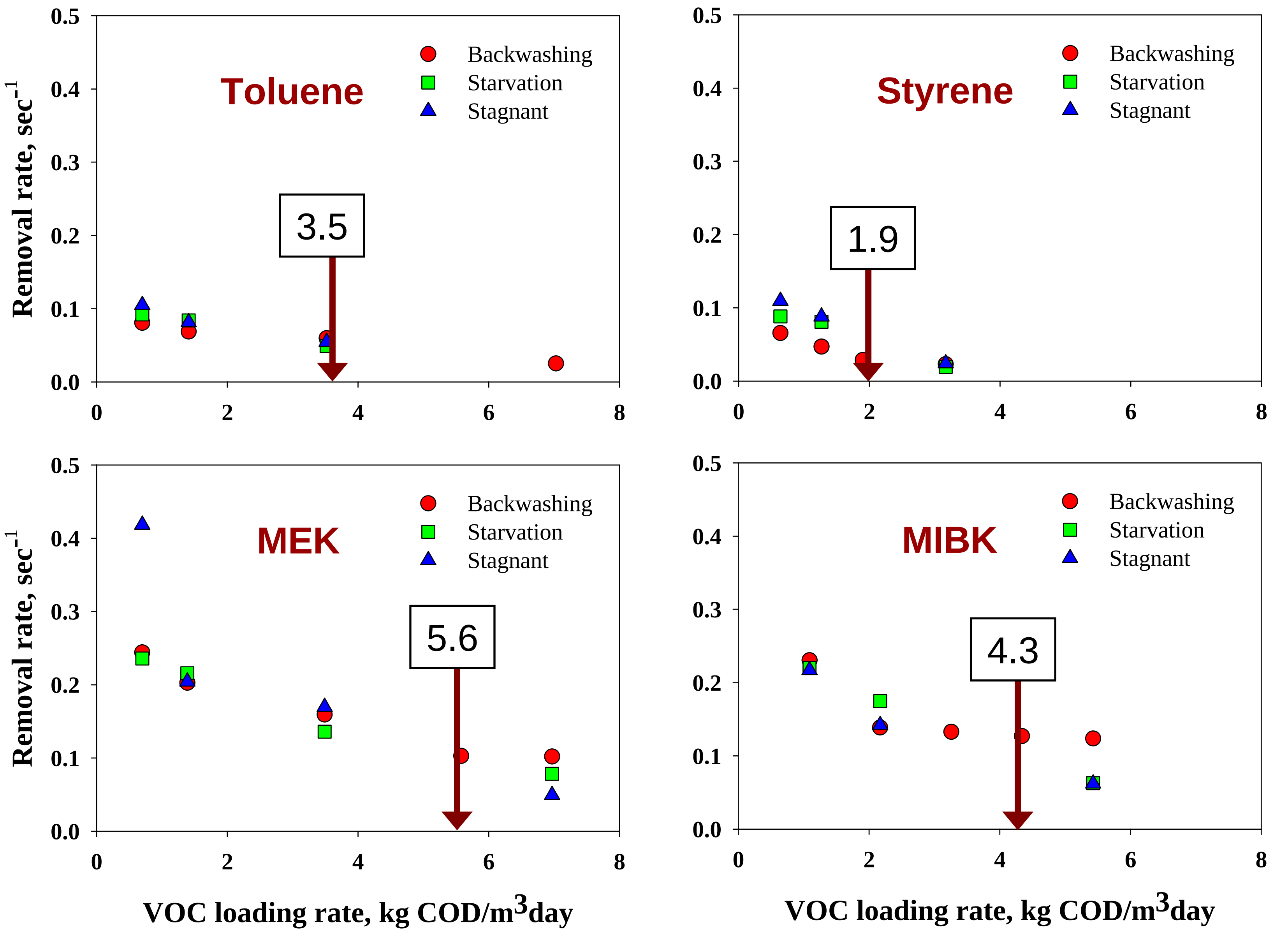
- Removal performance as a function of bed depth
  - backwashing
  - starvation
  - stagnant
- First-order removal rates (at different loading)



Results: Removal rates



Results: Removal rates



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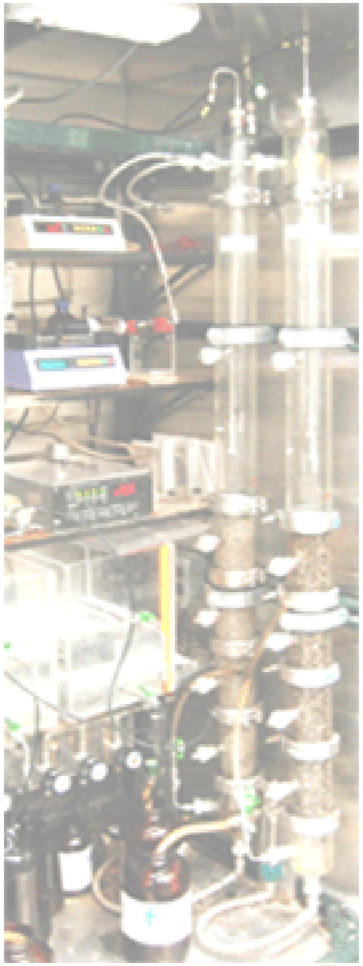
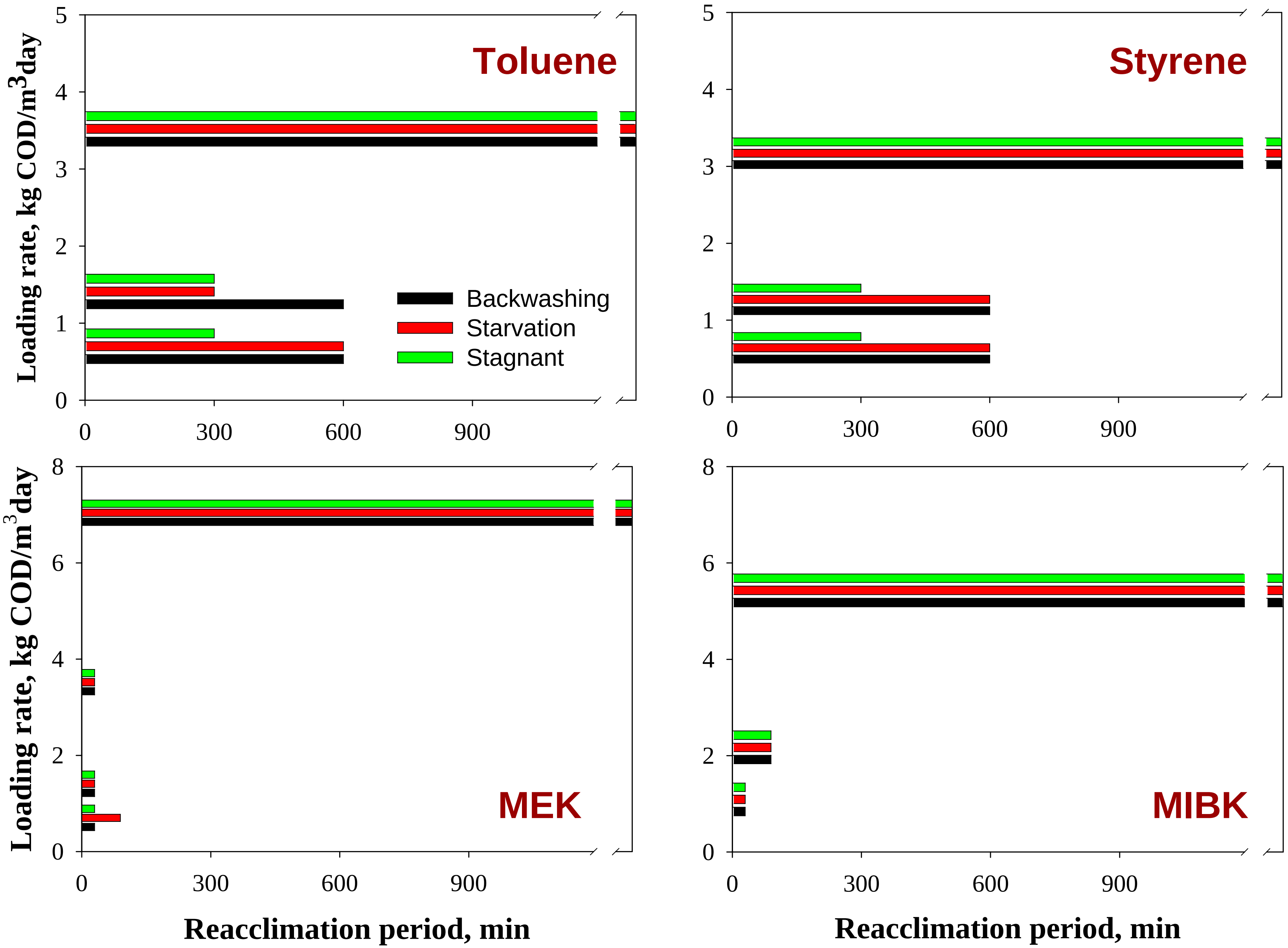
Results



Biofilter response after non-use periods

- Reacclimation period to reach the 99 % removal

Results: Reacclimation periods



Conclusions

1. Single paint booth VOCs were controlled very efficiently by TBAB with critical loading (kg COD/m^3·day) to attain 99 % removal.

   Toluene: 3.5

   Styrene: 1.9

   MEK: 5.5

   MIBK: 4.3

2. Removal capacity for VOC was a function of K_{ow} (Octanol-water partition coefficient)

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Conclusions

3. Up to critical loading rate, non-use periods can be considered as another means of biomass control

4. Reaction rates decreased as loading rate was increased

5. Biofilter response after stressed operating conditions was strongly dependant on the active biomass in the bed

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Acknowdgements

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- Dr. George A. Sorial
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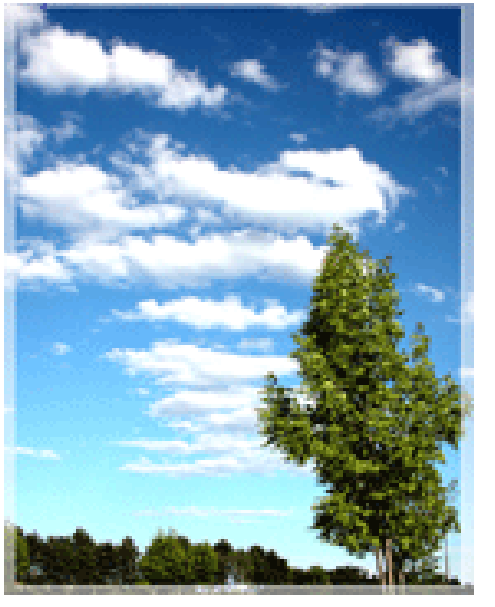

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