A&WMA's 98th Annual Conference and Exhibition

Feasibility of Adsorption/Desorption Cycles In a Two-Bed Adsorption Unit For Dampening Biofilter Performance Fluctuation

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- Theory of This Study
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- Conclusion

Feasibility of Adsorption/Desorption Cycles
In a Two-Bed Adsorption Unit
For Dampening Biofilter Performance Fluctuation

Introduction

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Introduction

Conceptually identical process to the biofilter

- Microbial attachment: Synthetic inorganic media
- Intermittent delivery of Nutrient & Buffer to the media

Trickle-Bed Air Biofilter (TBAB)

- **Consistent Nutrient & pH control**
- **Optimizing the waste utilizing kinetics**

Introduction

For more successful application in industry

Challenges

Source Characteristics

- Transient loading
- Non-use periods
- VOCs composition

Biofilter Maintenance

- Biomass accumulation
- Microbial activity

Load fluctuation

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Introduction

Load fluctuation

Solution = Buffer unit

Adsorption unit can be a buffer unit for a biofilter

Current application : Single bed of carbon filter

Consideration of current adsorption unit

High loading & Large fluctuation → Losing buffer capacity

Initial period of operation → No contaminant to biofilter

Feasibility of Adsorption/Desorption Cycles In a Two-Bed Adsorption Unit For Dampening Biofilter Performance Fluctuation

Objective

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Objective

Main Objective

A 2-bed adsorption unit is proposed to establish long-term stable buffer capacity of adsorption unit in mitigating biofilter performance

Specfic Objective

- To design and evaluate a 2-bed adsorption unit
- To evaluate the overall performance of a combined process scheme (2-bed adsorption unit + Biofilter)
- To be compared with that of a control unit without adsorption unit (Biofilter)

Feasibility of Adsorption/Desorption Cycles In a Two-Bed Adsorption Unit For Dampening Biofilter Performance Fluctuation

Theory of 2-Bed Adsorption

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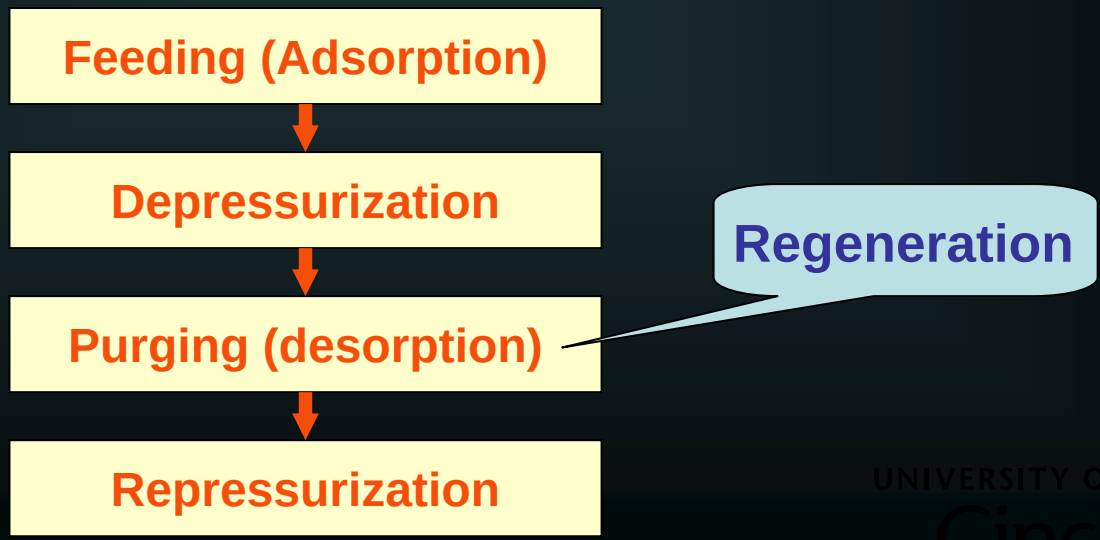
Theory of 2-Bed Adsorption

2-Bed Adsorption Unit

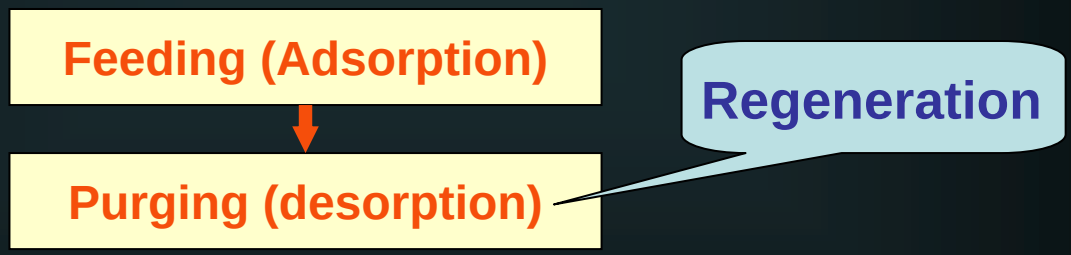
- Conceptually simple process to PSA
- PSA (Pressure Swing Adsorption) :
  → A technology for separation and purification for gas mixtures
  → 4 Steps for operational function



Theory of 2-Bed Adsorption

2-Bed Adsorption Unit

- Hypothetically, if adsorption rate is equal to its desorption rate
  → Operational function is simplified to a 2-step

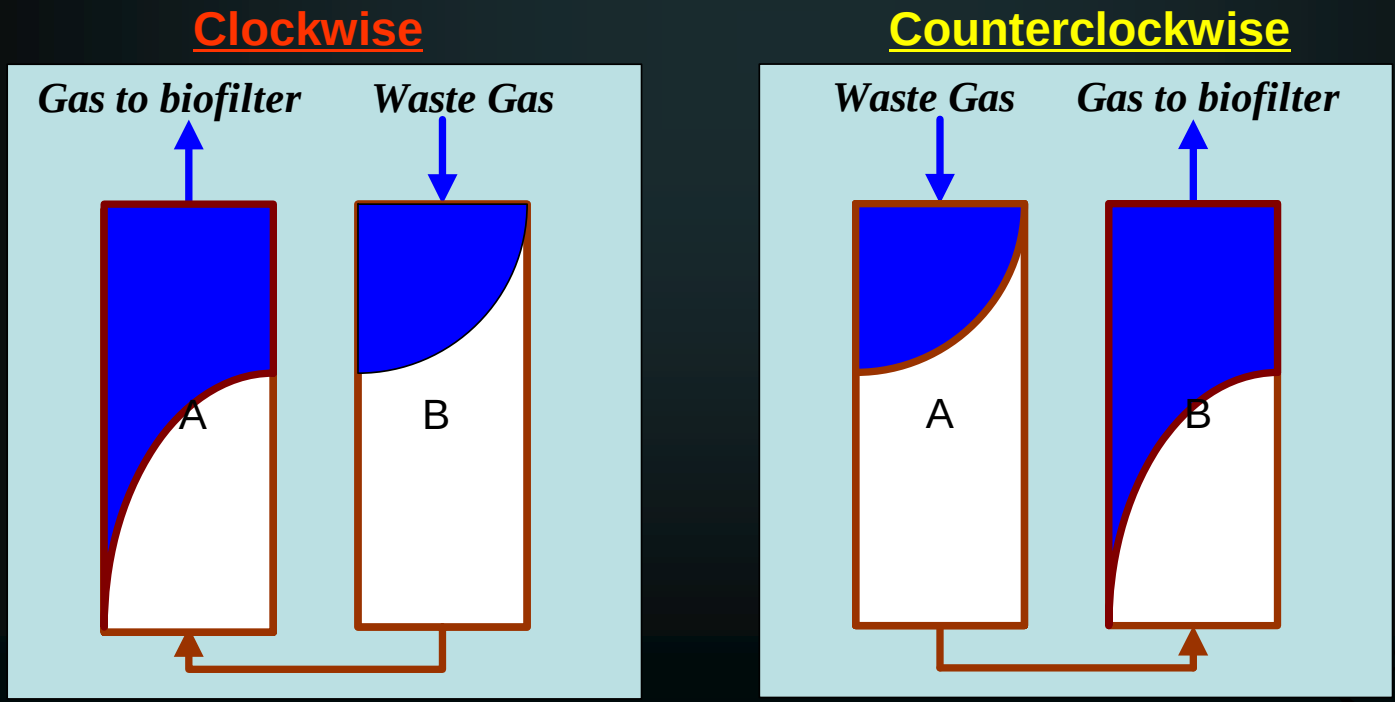


Theory of 2-Bed Adsorption

2-Bed Adsorption Unit

- Cyclic operation : Shift of air flow direction

  → Each bed will not be fully saturated with adsorbate



Theory of 2-Bed Adsorption

2-Bed Adsorption Unit

Will Serve as

- Polishing unit during the initial acclimation period of the biofilter
- Buffer unit in load fluctuation
- Feeding source without any feeding phase during non-use periods

Feasibility of Adsorption/Desorption Cycles
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Materials and Methods

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Feeding Condition

Targeted VOC

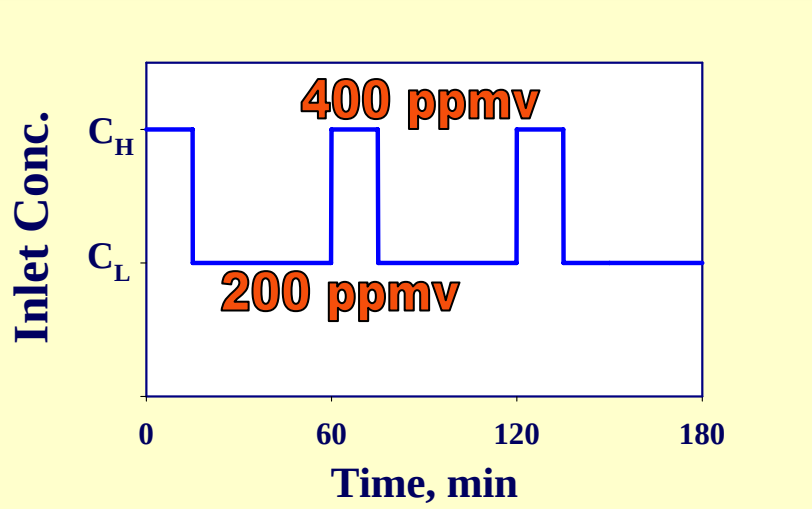
Toluene (C_7H_8)

- Comment solvent employed in the industry
- A major component in paints and varnishes

Concentration & Loading

Square Wave Change

- Base = 200 ppmv
- Peak = 400 ppmv (15 mins / hour)
- Average concentration : 250 ppmv



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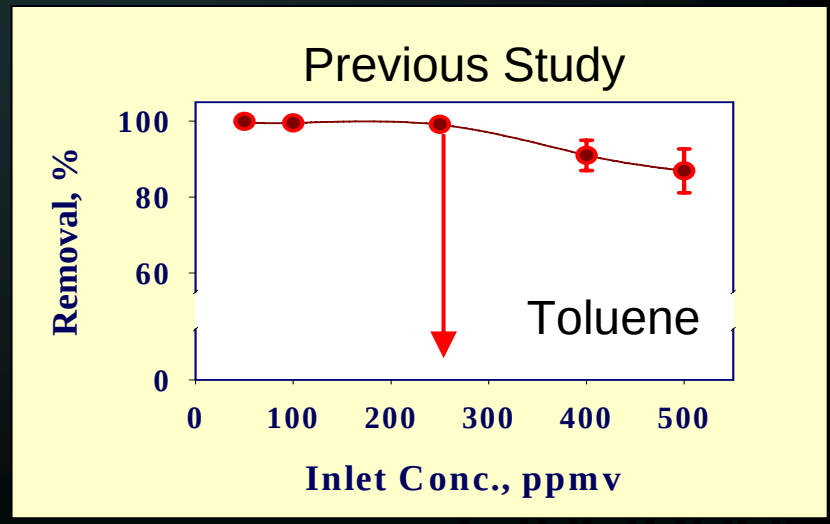

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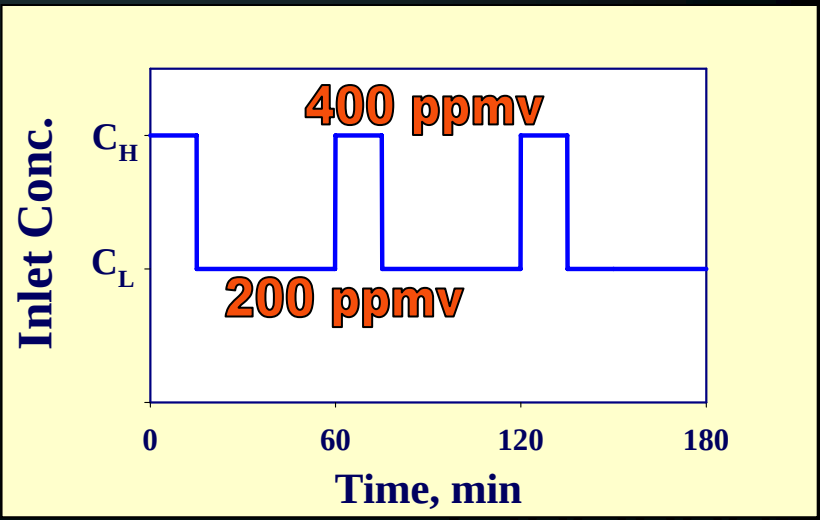
- Average loading rate : 46.9 g/m^3·hr



Materials and Methods

Adsorption Unit

- 2 Beds
- Dimension : 2.5 cm (D) × 20 cm (L)
- Duration of one cycle : 8 hours
- EBRT: 5.6 sec (2.2 L/min)

- Absorbent : GAC (BPL 6 × 16)

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Materials and Methods

Biofilter

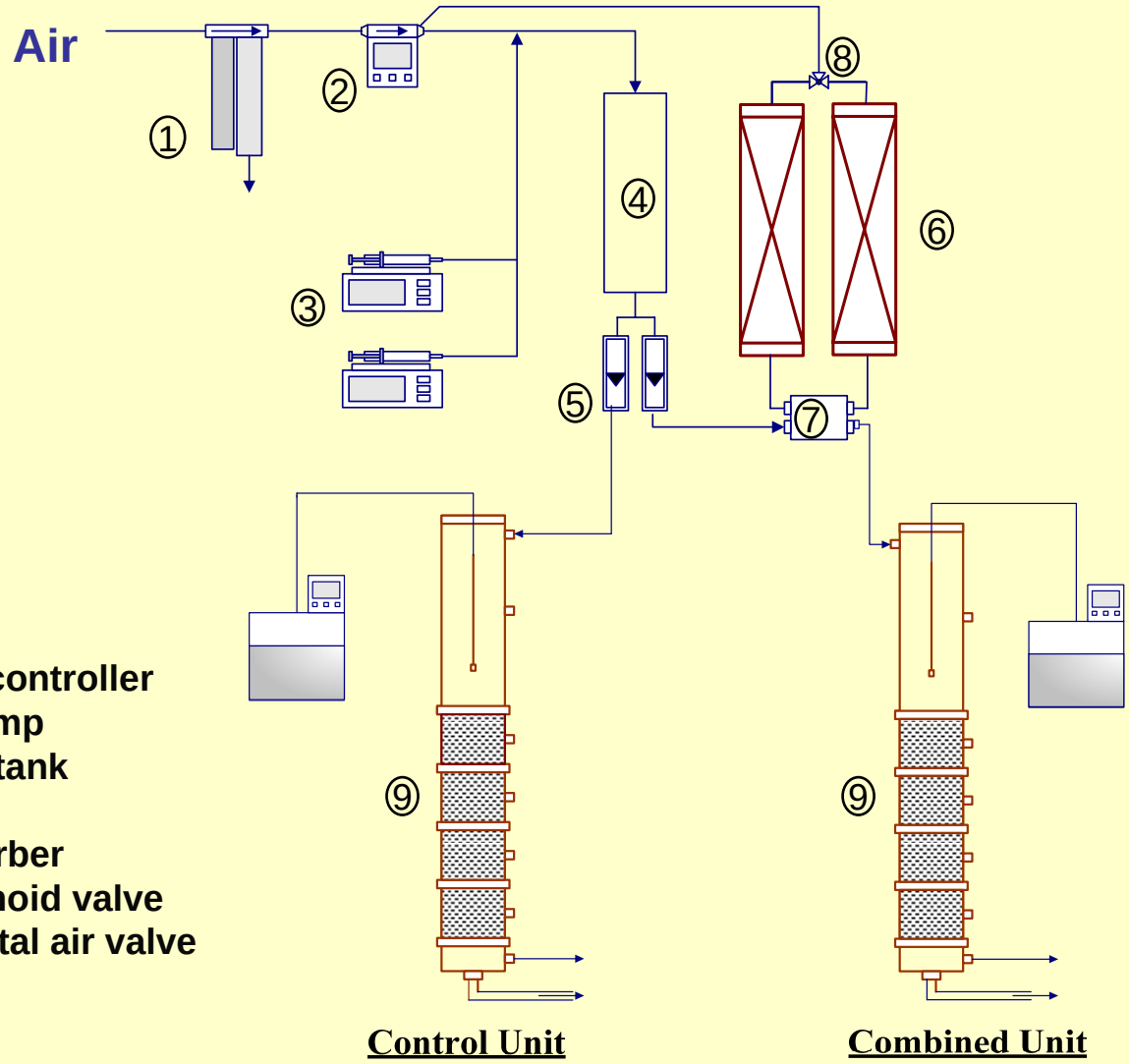
Trickle Bed Air Biofilter (TBAB)

- Dimension : 76 mm (D) × 130 cm (L)
- Buffered nutrient solution supply
- Operating Temp. : 20 °C
- EBRT: 1.2 min (2.2L/min)

Media

- Celite® 6 mm R-635 Bio-Catalyst Carrier
- Packing depth : 60 cm
- Seeded with aerobic microbial culture pre-acclimating to toluene

Schematic Diagram of Experimental Setup



1. Air cleaner
2. Mass flow controller
3. Syringe pump
4. Equalizing tank
5. Flow meter
6. 2-bed adsorber
7. 4-way solenoid valve
8. Supplemental air valve
9. Biofilter

Feasibility of Adsorption/Desorption Cycles
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Experimental Results

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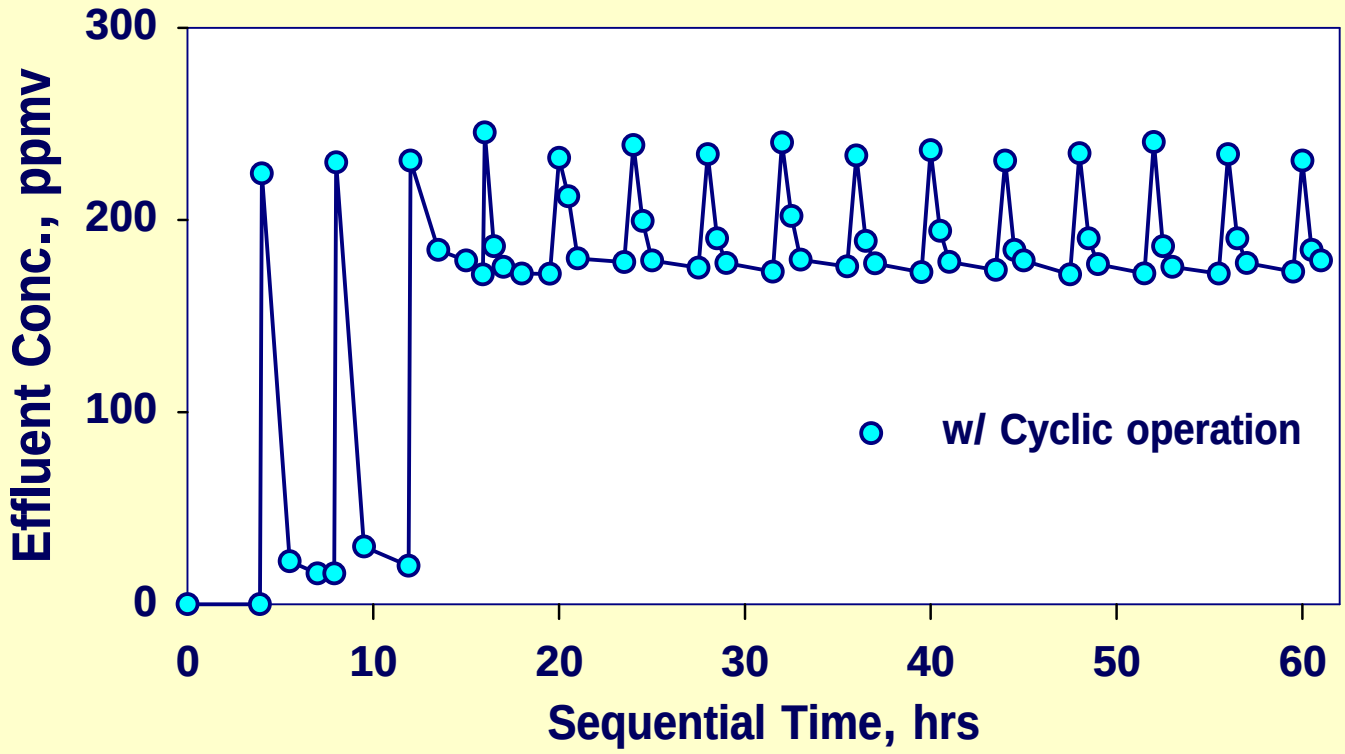
2-Bed Adsorption Performance

Square wave change of inlet concentration



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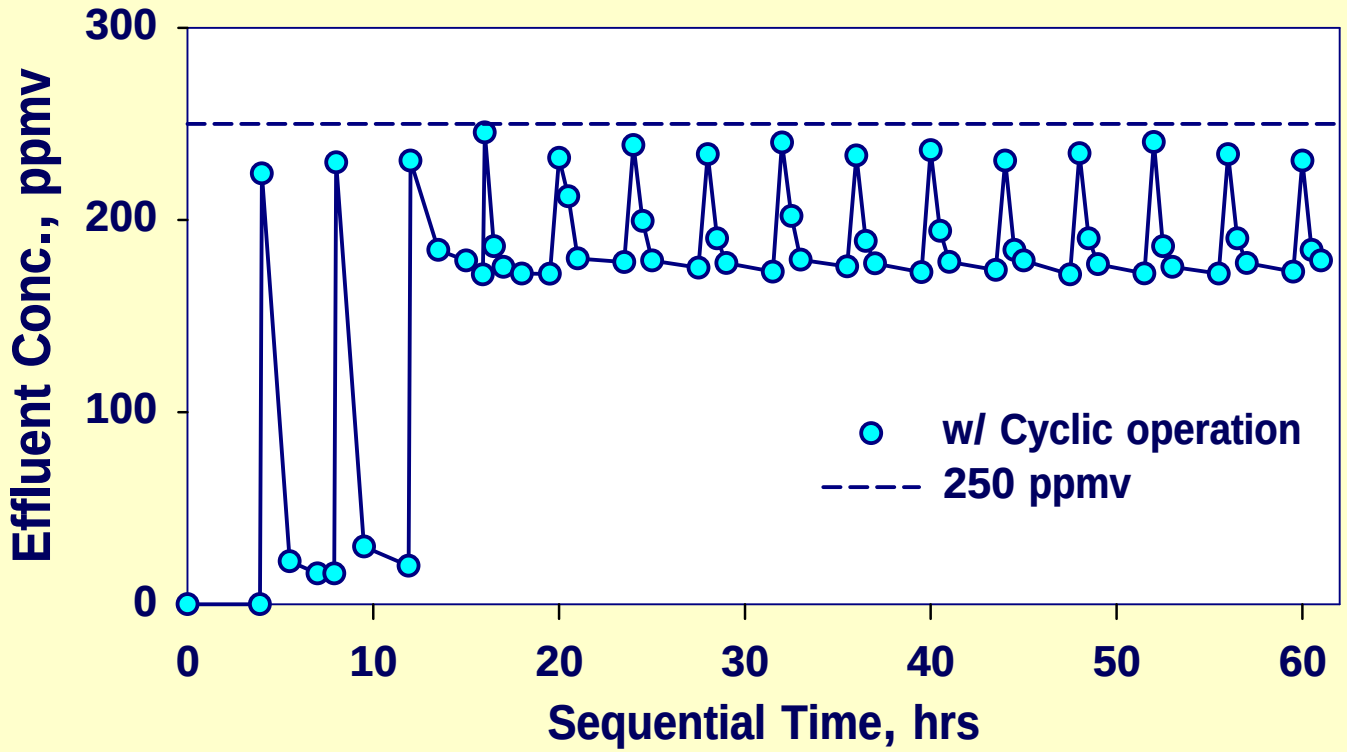

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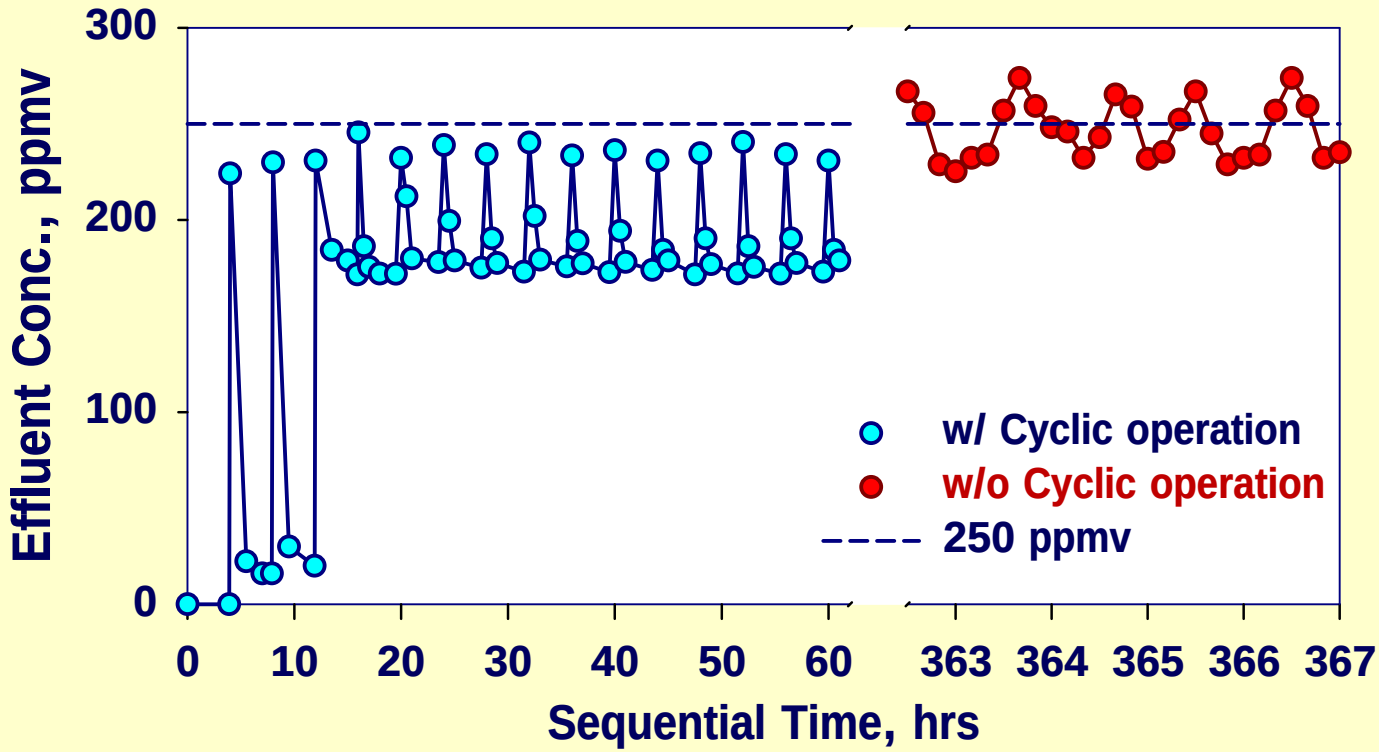
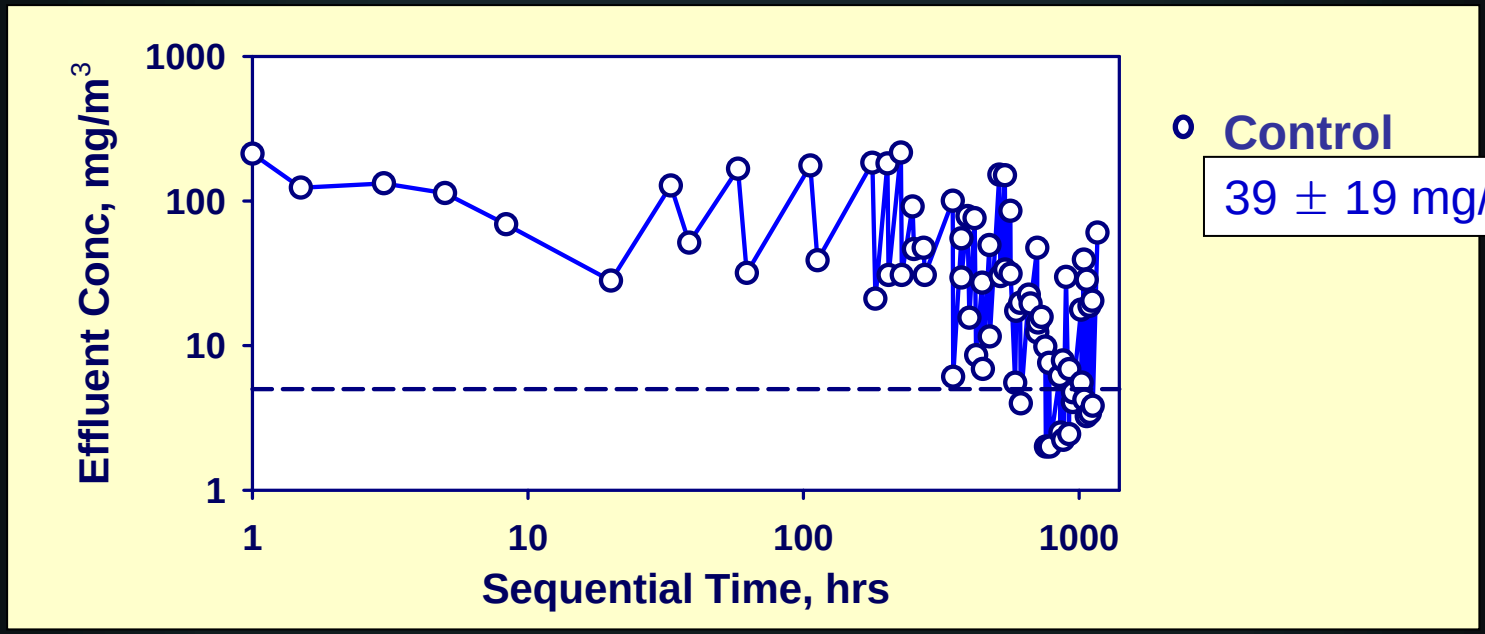


Toluene Removal Performance

Effluent Concentration



Exposure guideline (10 hrs average) : 5 mg/m^3 (AIHA)

Toluene Removal Performance

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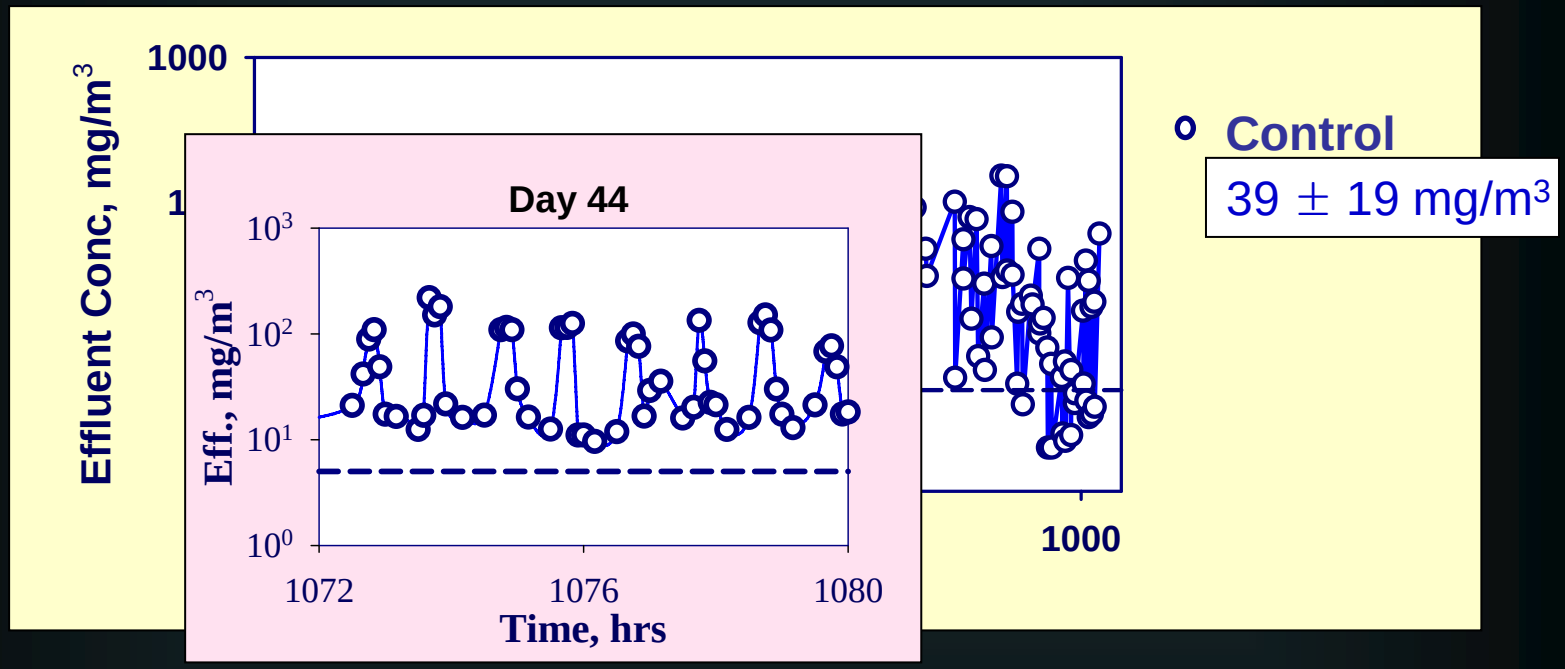

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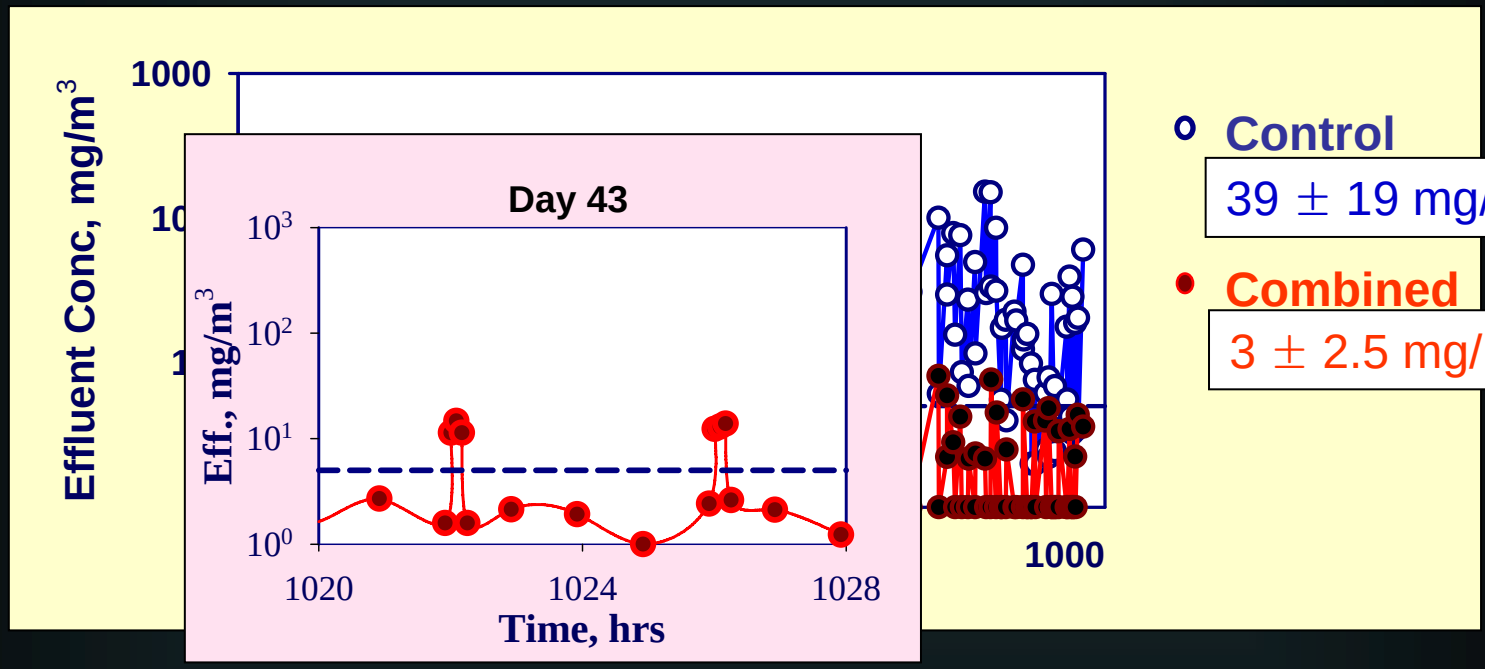

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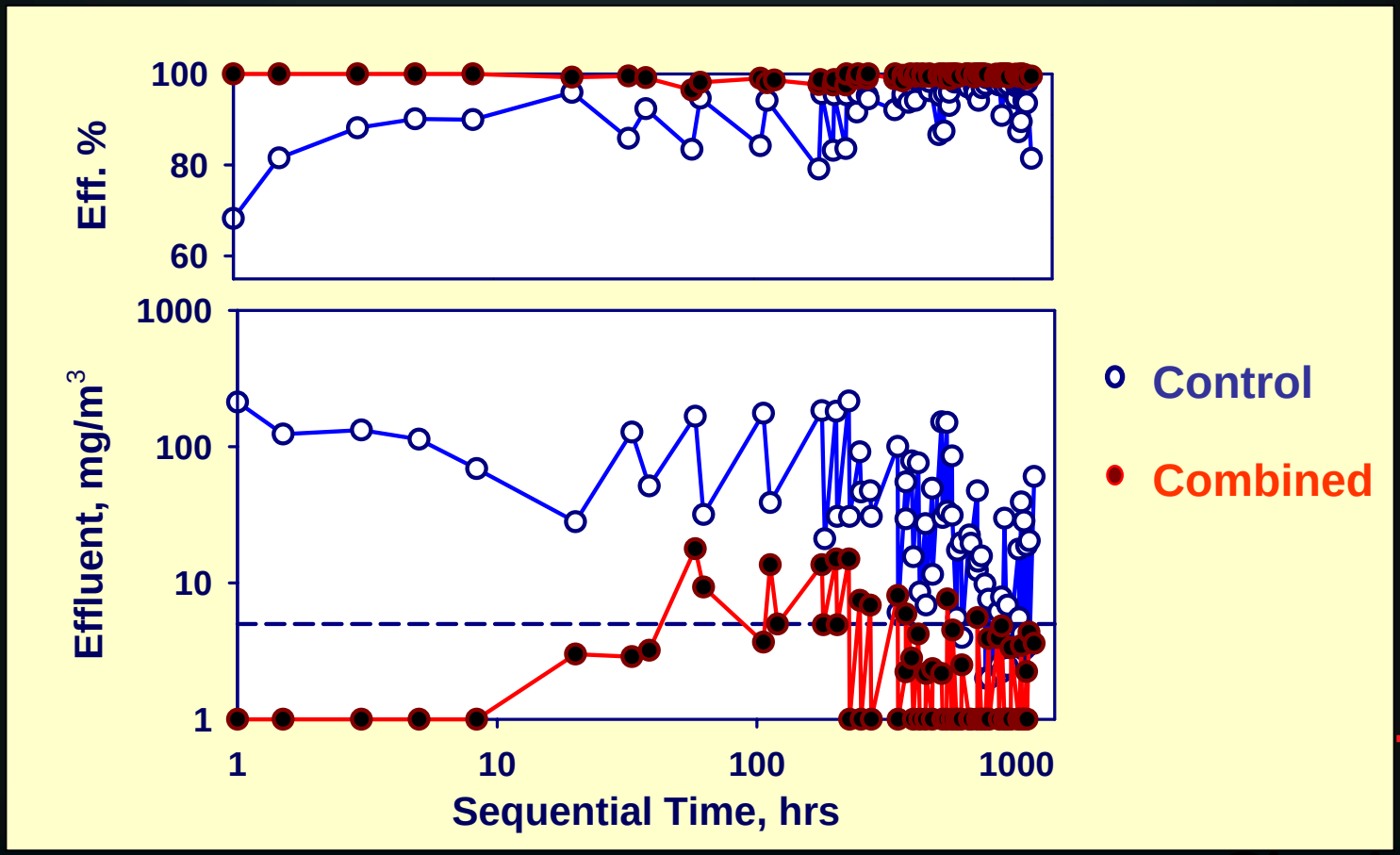
Toluene Removal Performance

Removal Efficiency



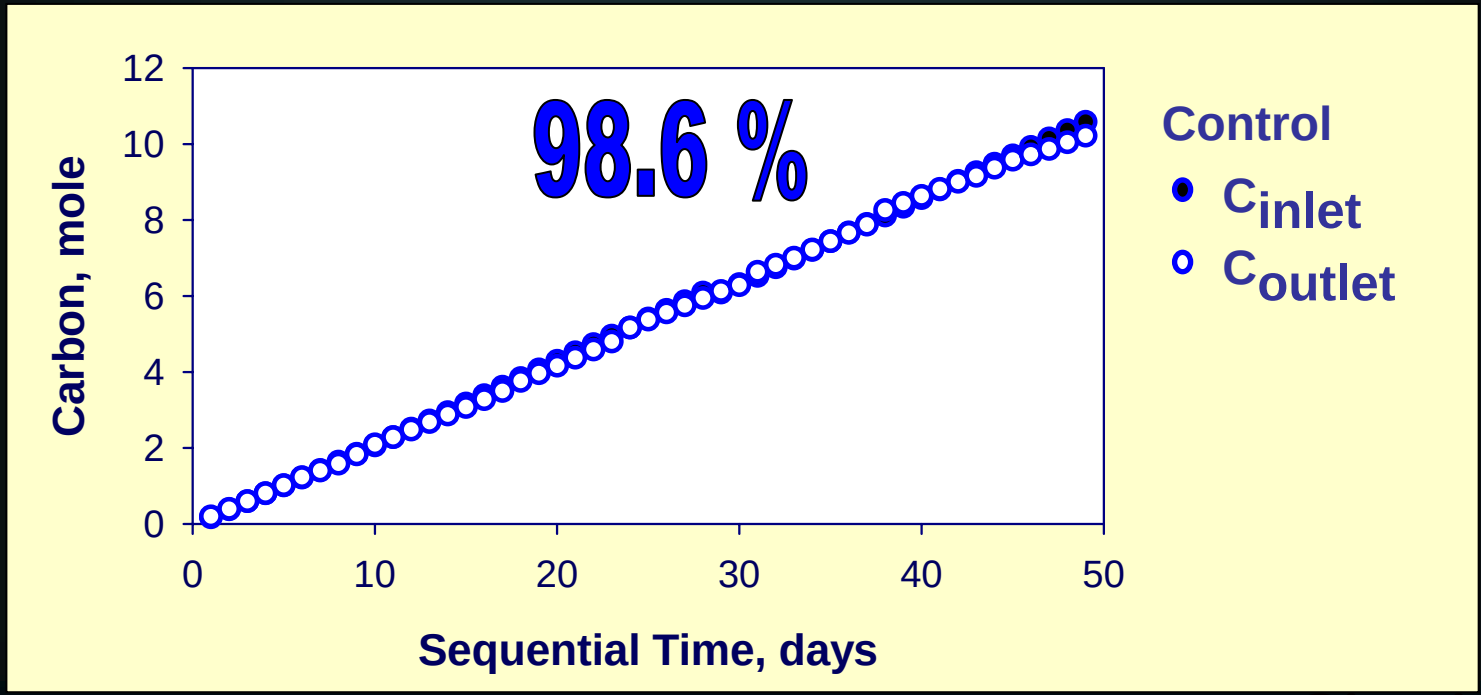
How much saturated?

1. Carbon mass balance (Combined unit)

2. Adsorption performance (Adsorption beds)

Carbon Balance

C_{inlet} (toluene removed) vs. C_{outlet} (net gas & liquid effluent)



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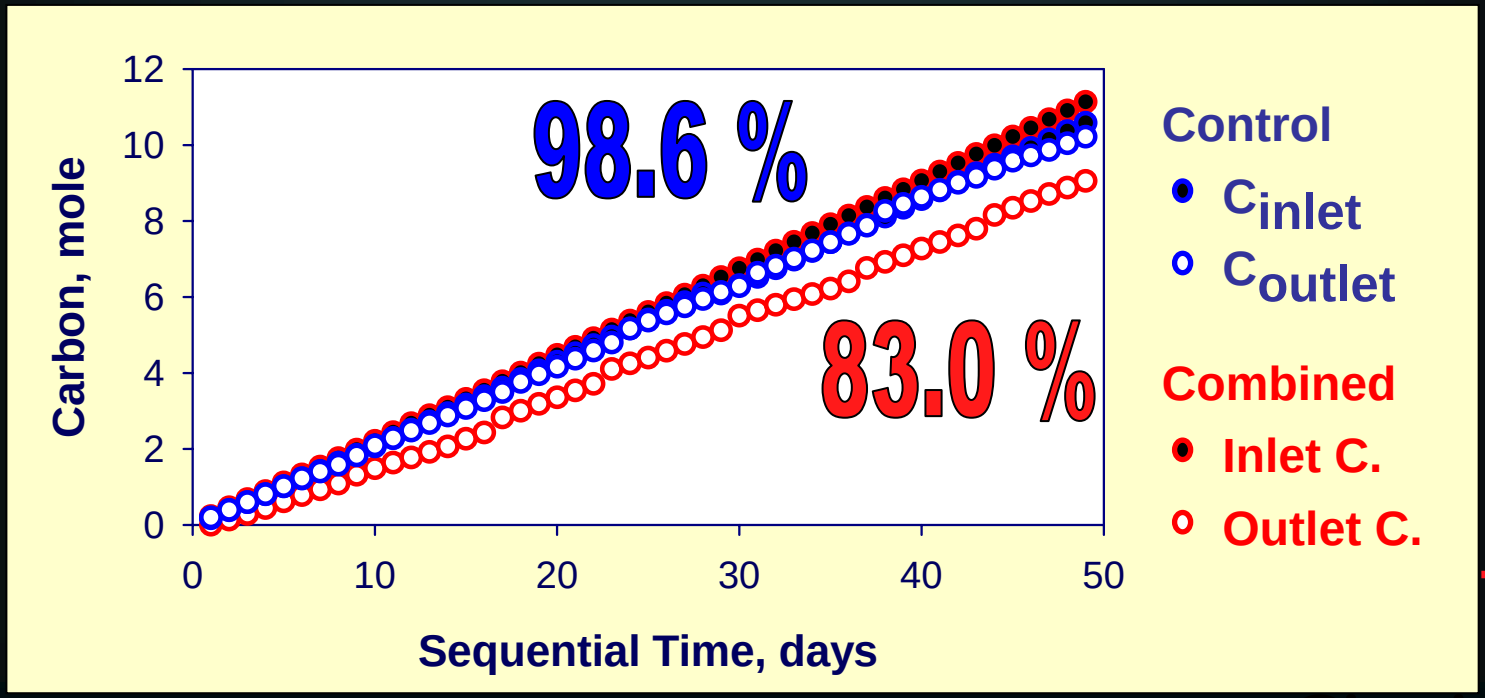

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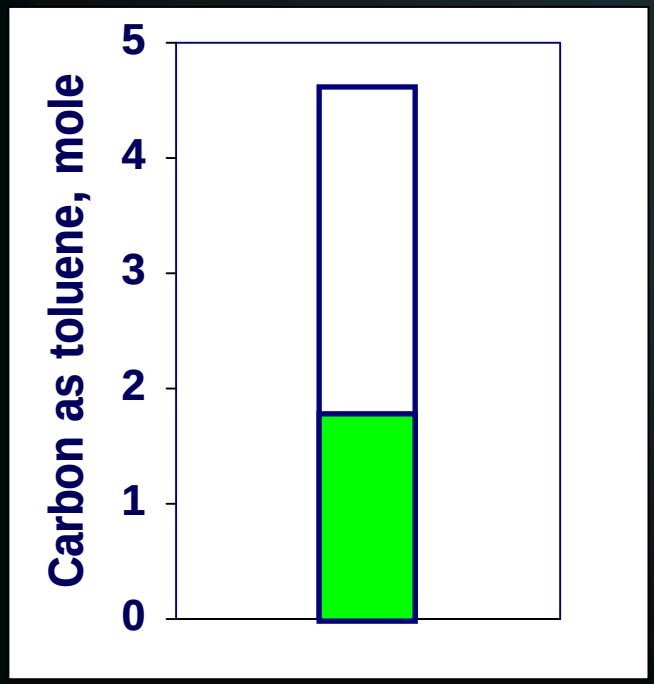

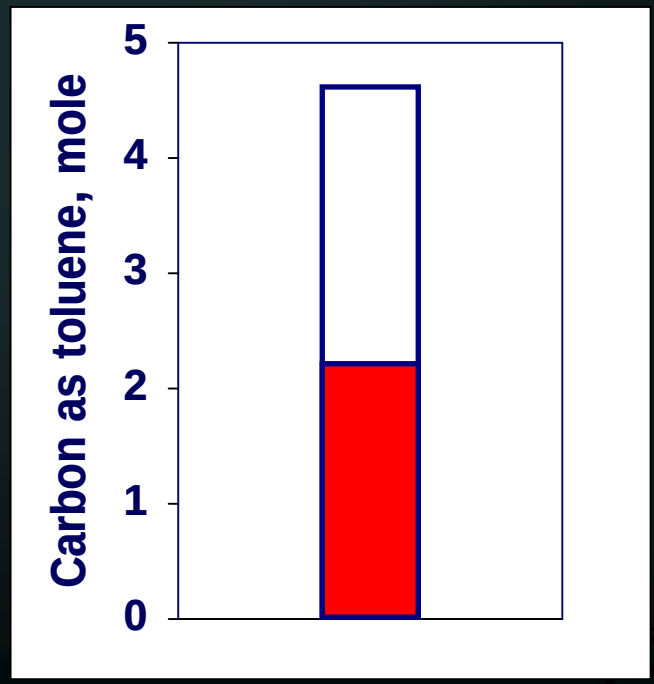

Effect of Non-Use Periods

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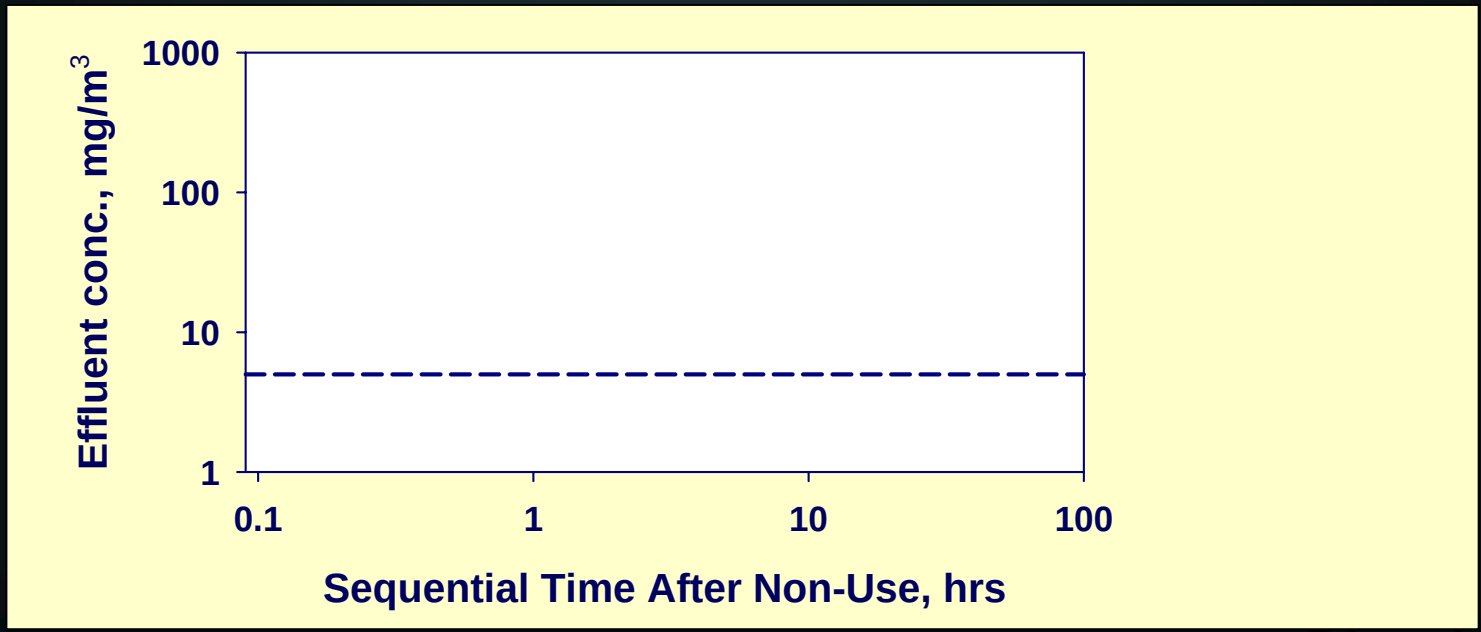
Reacclimation

Effluent response after 2 days of starvation



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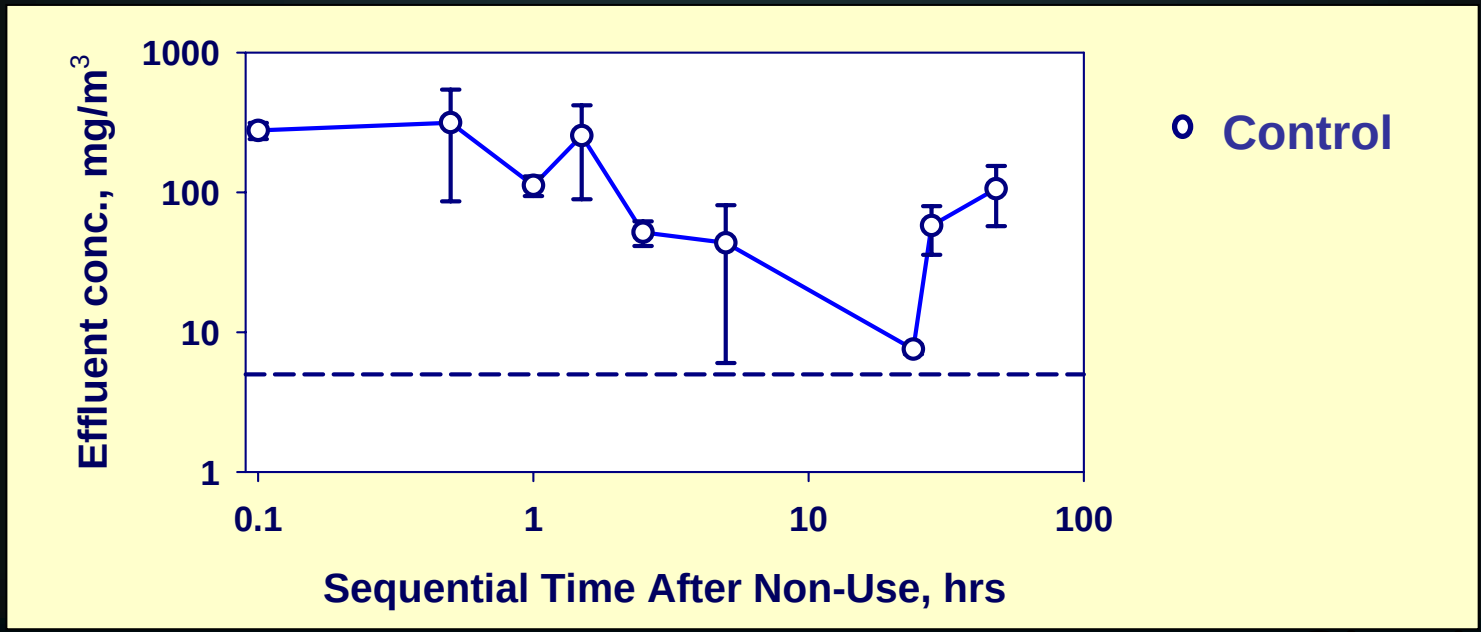

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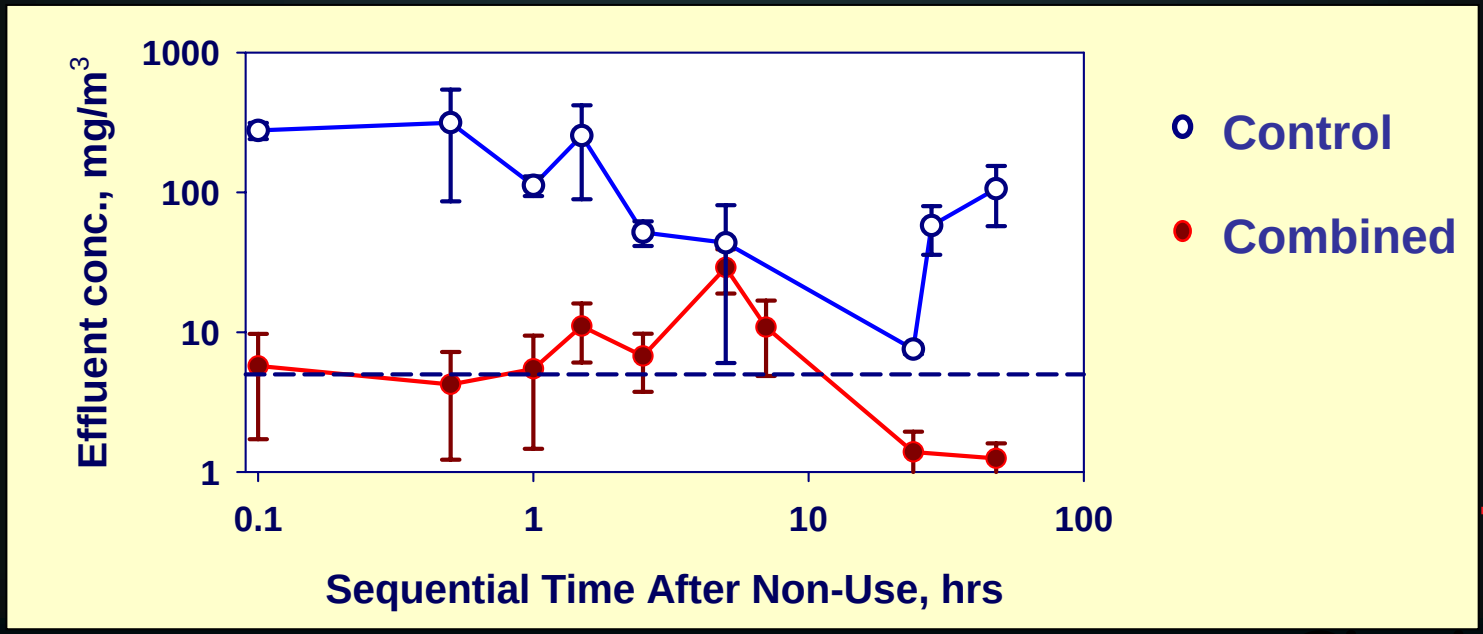


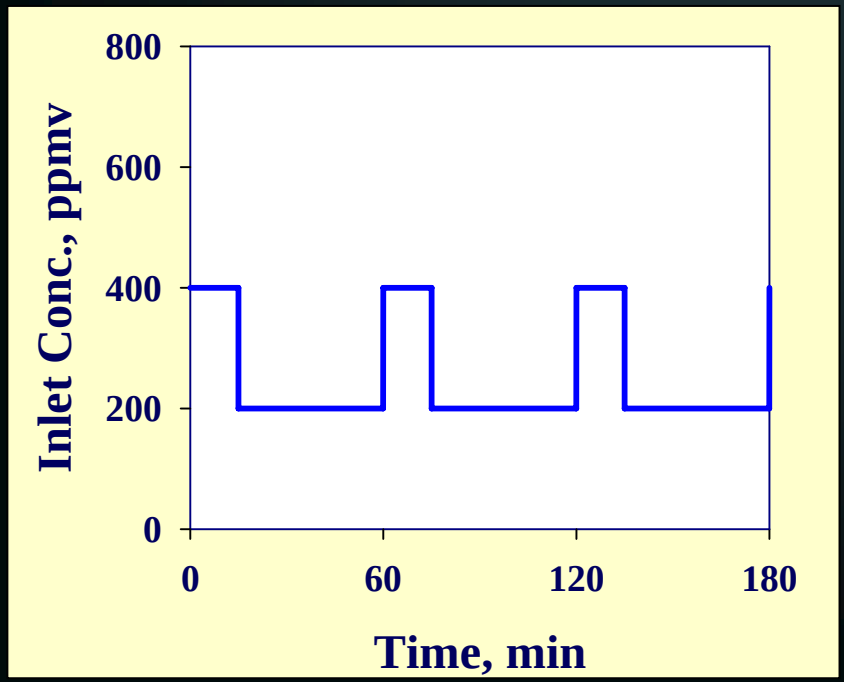
Further Application

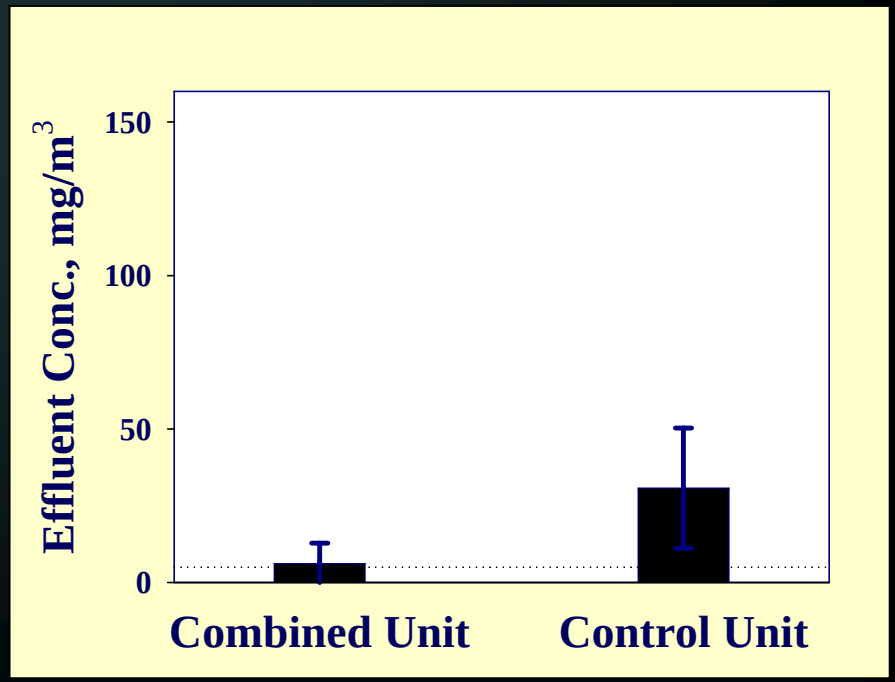
Feeding Conditions

Further Application

Feeding Conditions

- 1st : 46.9 g/m^3·hr

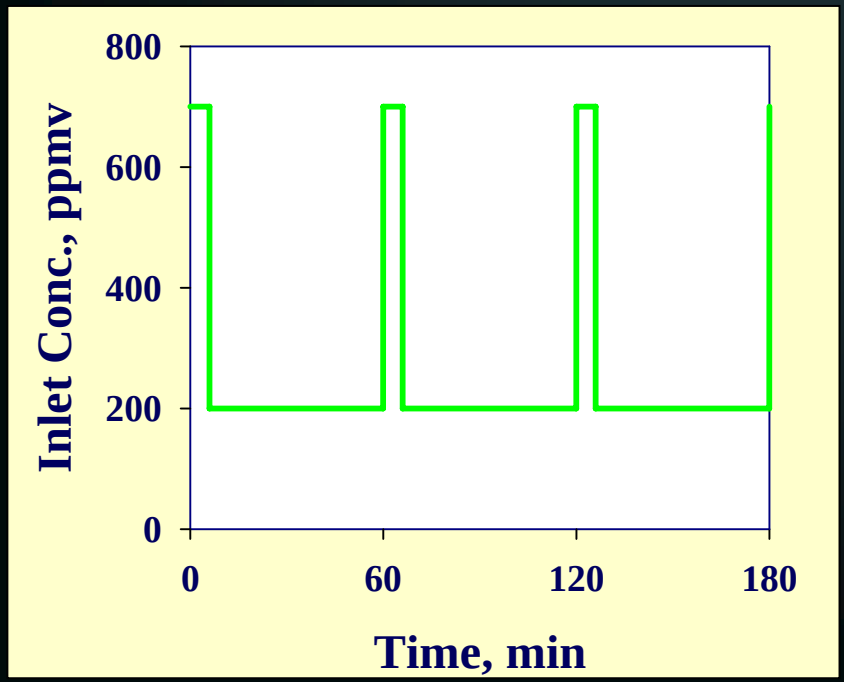


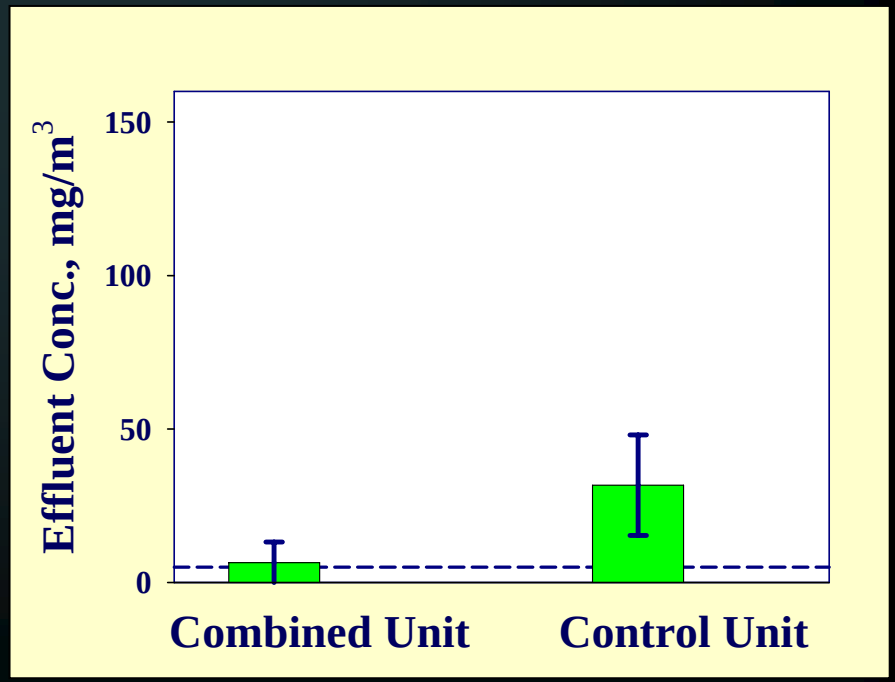


Further Application

Feeding Condition

- 2nd : High concentration of peak, 46.9 g/m^3·hr

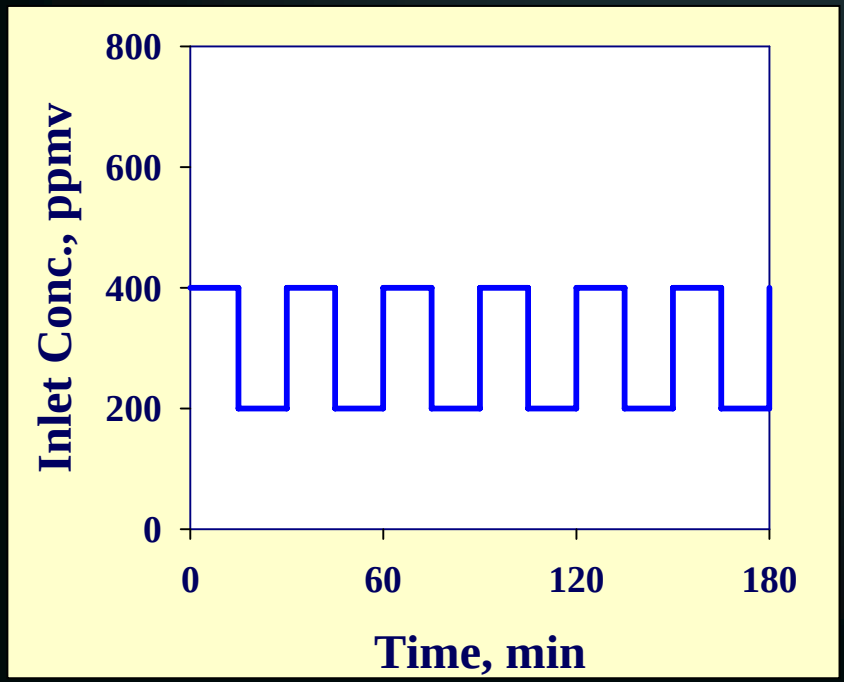


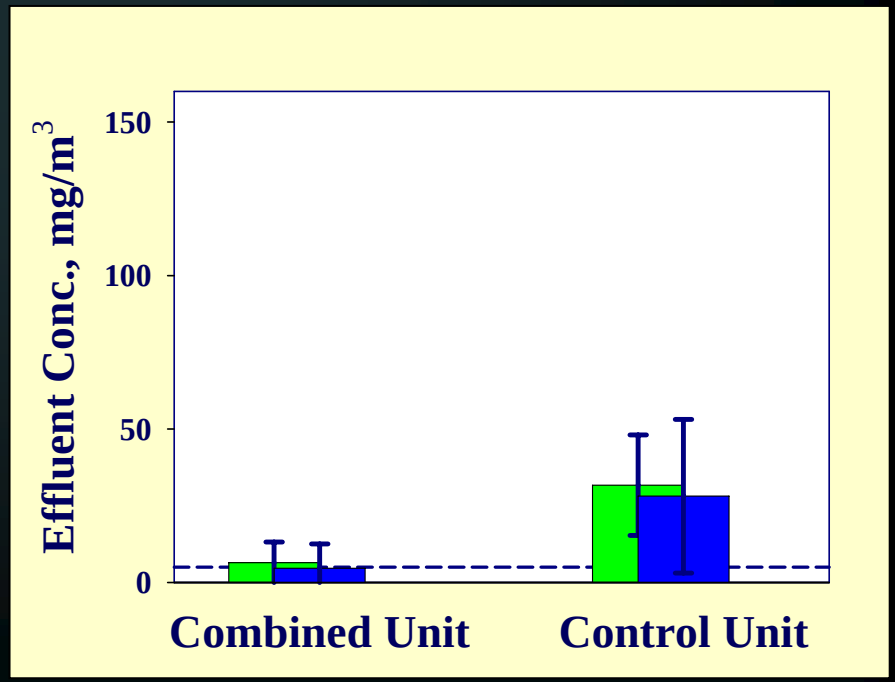


Further Application

Feeding Condition

- 2nd : High concentration of peak, 46.9 g/m^3·hr
- 3rd : Frequent peak, 56.3 g/m^3·hr

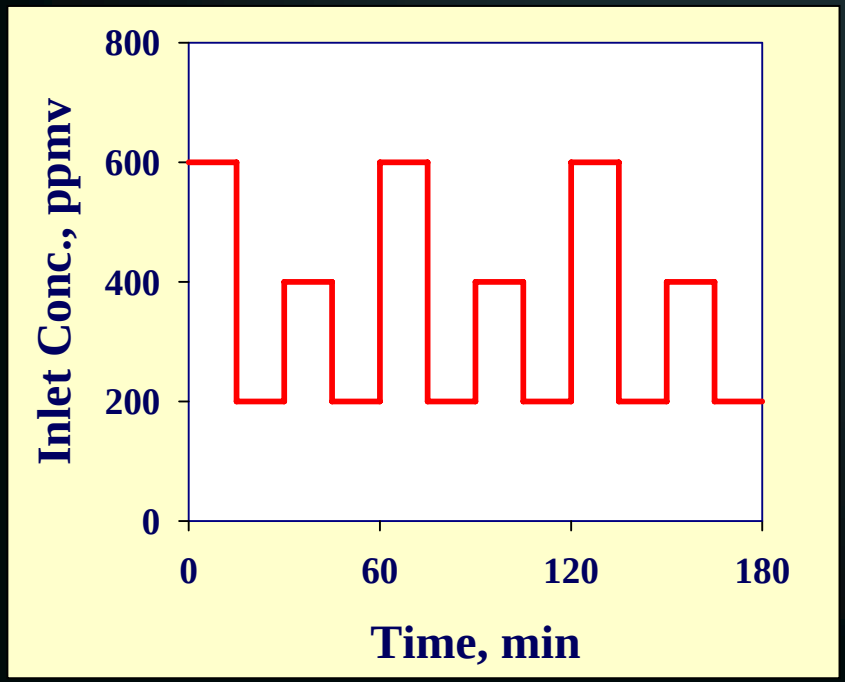


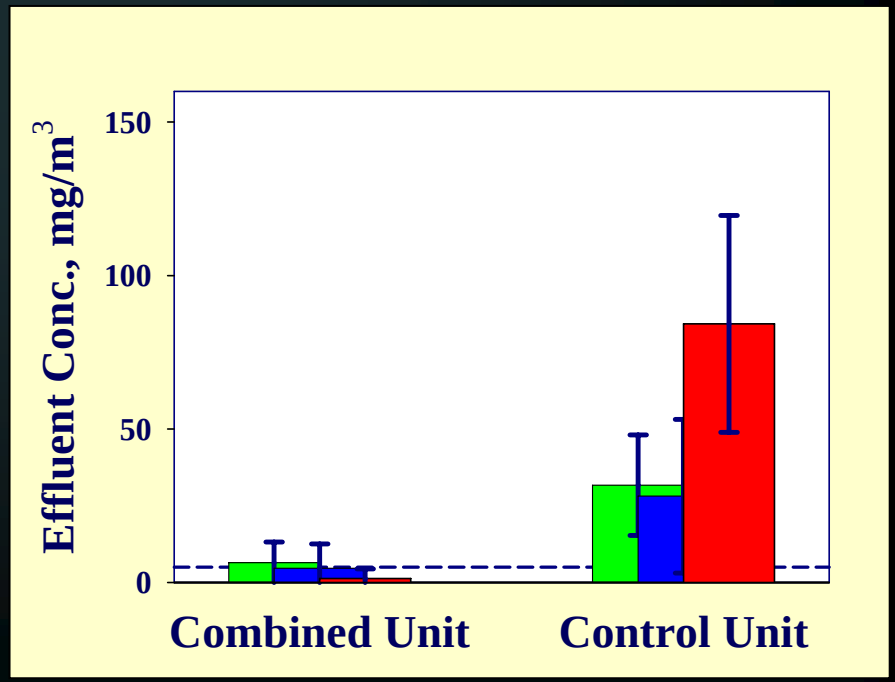


Further Application

Feeding Condition

- 2nd : High concentration of peak, 46.9 g/m³·hr
- 3rd : Frequent peak, 56.3 g/m³·hr
- 4th : High con. and frequent peak, 65.9 g/m³·hr





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Conclusion

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Conclusion

During unsteady-state loading conditions,

The 2-step of adsorption and desorption cycle in a 2-bed adsorption mitigated the adverse effect of load fluctuation on biofilter performance

The 2-Step cycle, i.e., adsorption and desorption,

functioned as

- A polishing unit to abate the initial acclimation for the biofilter
- A buffering unit to dampen the biofilter performance
- A feeding source to the biofilter during non-use periods

Acknowledgements

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