

# ***Ex-Situ* Biotreatment of MTBE/TBA-Impacted Groundwater**

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# Outline

- **Some Bioreactor Basics**
- **Operational Systems**
  - **Trickling Filter Bioreactors**
    - (UCR- Energy Resource Institute)
  - **Fluidized Bed Bioreactors**
    - (UCD- Environmental Resolutions Inc)
  - **BioGAC**
    - (Shell Global Solutions/Calgon)

# Key Bioreactor Issues

1. Provide organisms with nutrition and environmental conditions they need
2. Provide sufficient hydraulic retention time to meet treatment goals
3. Minimize loss/maximize retention of slow-growing oxygenate-degraders

# Give the Bugs What They Need!

**Good Food - MTBE & TBA**

**Potentially bad food - BTEX & TPH**

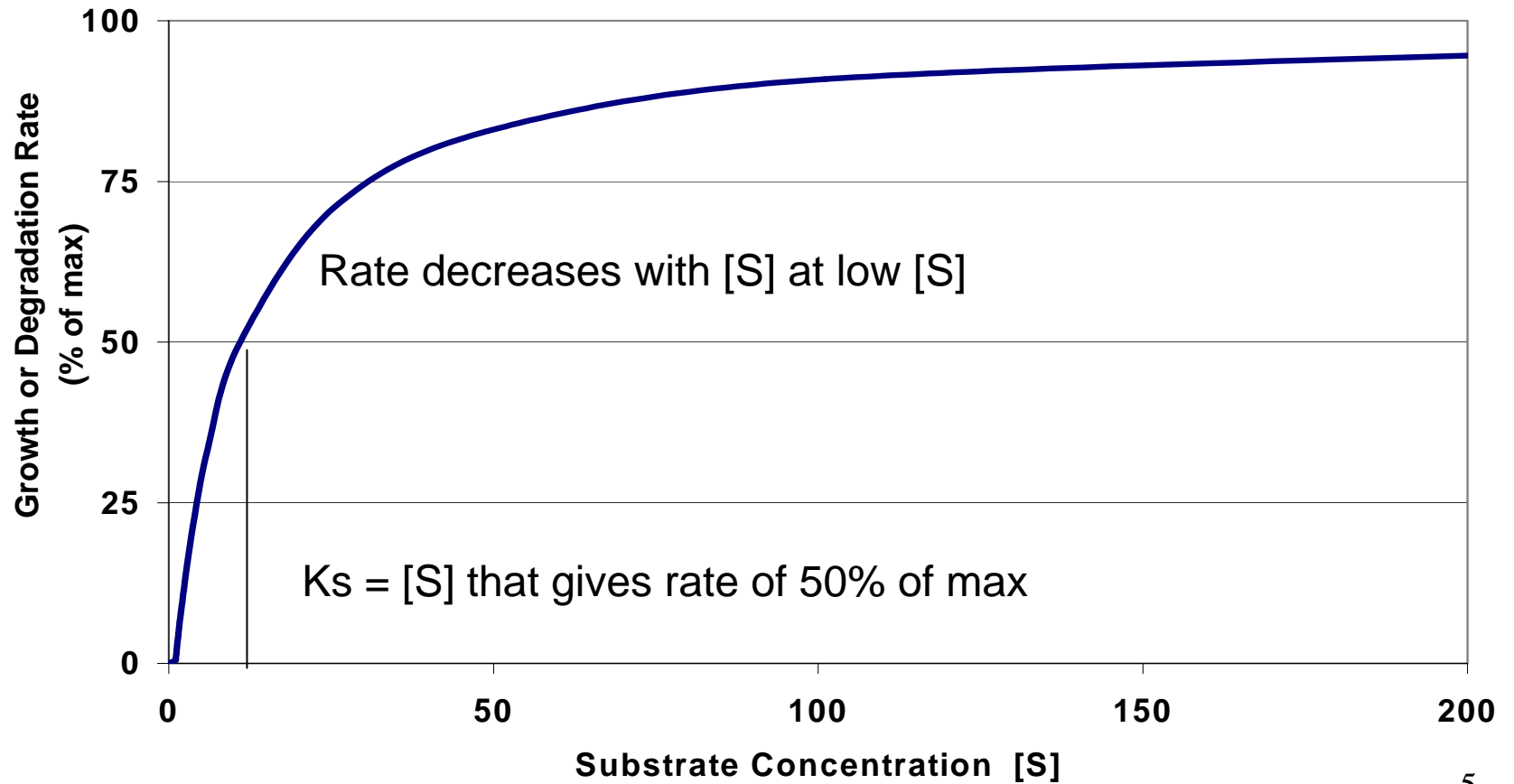
**Oxygen – *Ex-situ* treatment is aerobic**

**Nutrients – N and P (growth = activity)**

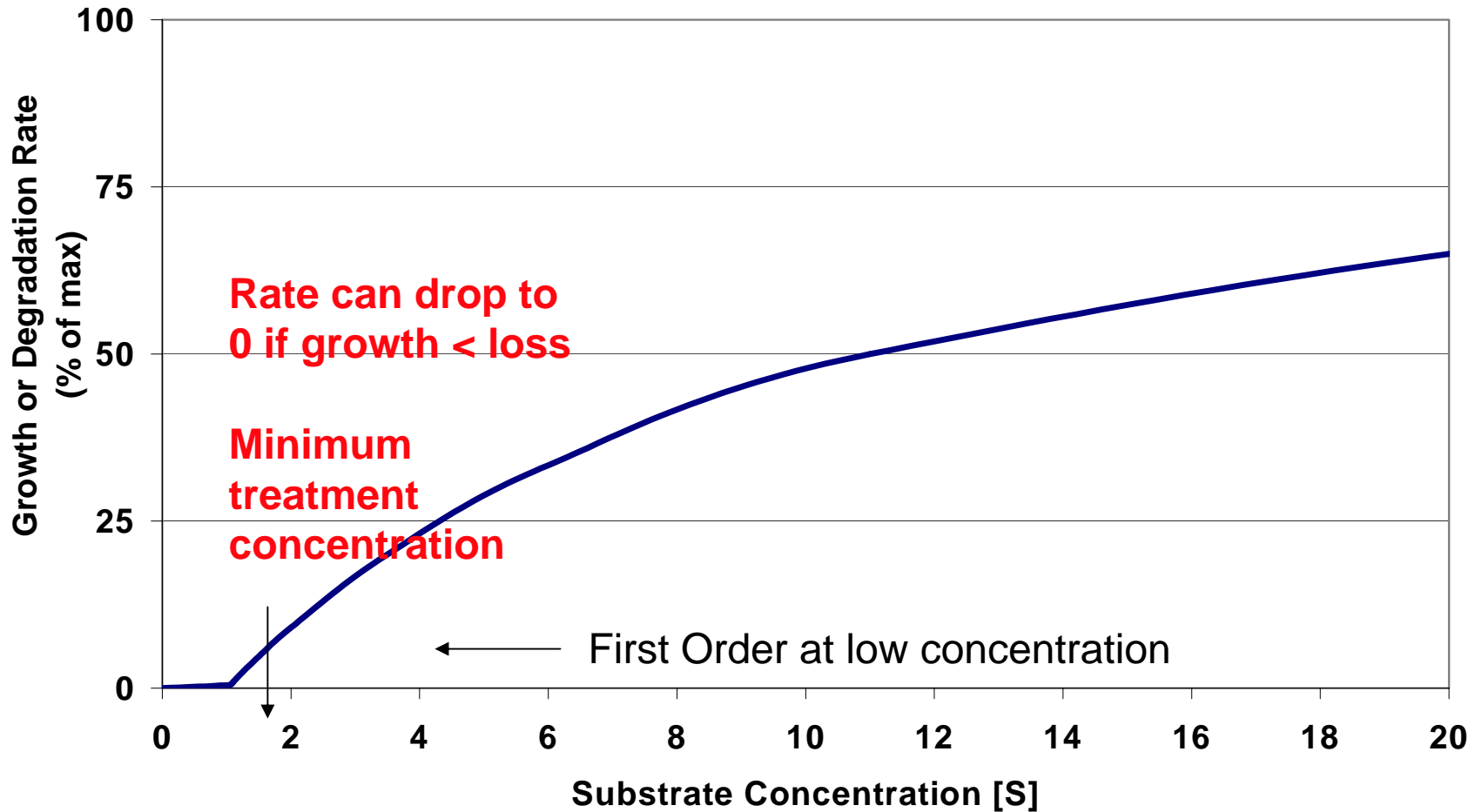
**Other conditions –temperature, pH**

**Surfaces/Retention of biomass**

# Food Supply & Degradation Kinetics



# There Can Be a Minimum!



# Oxygen supply and demand

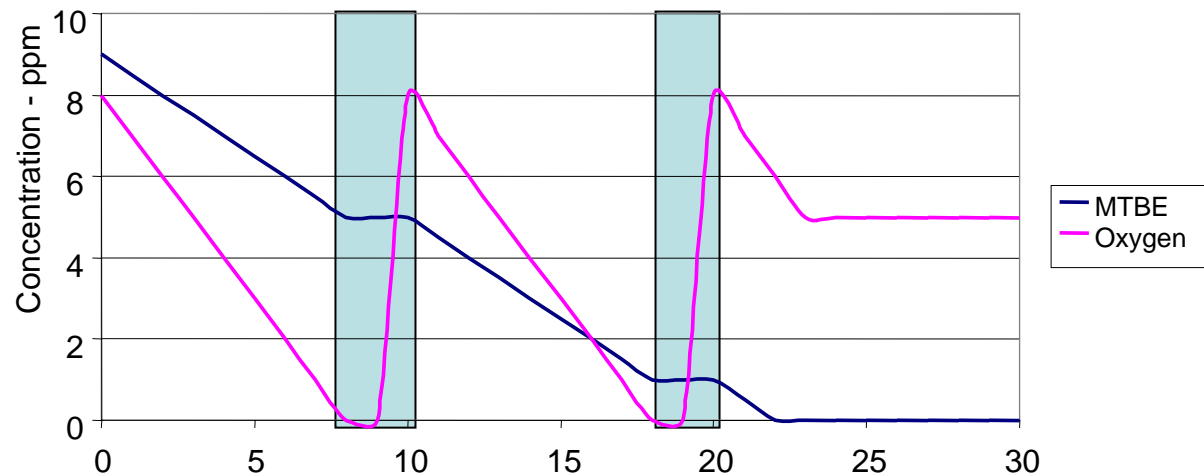
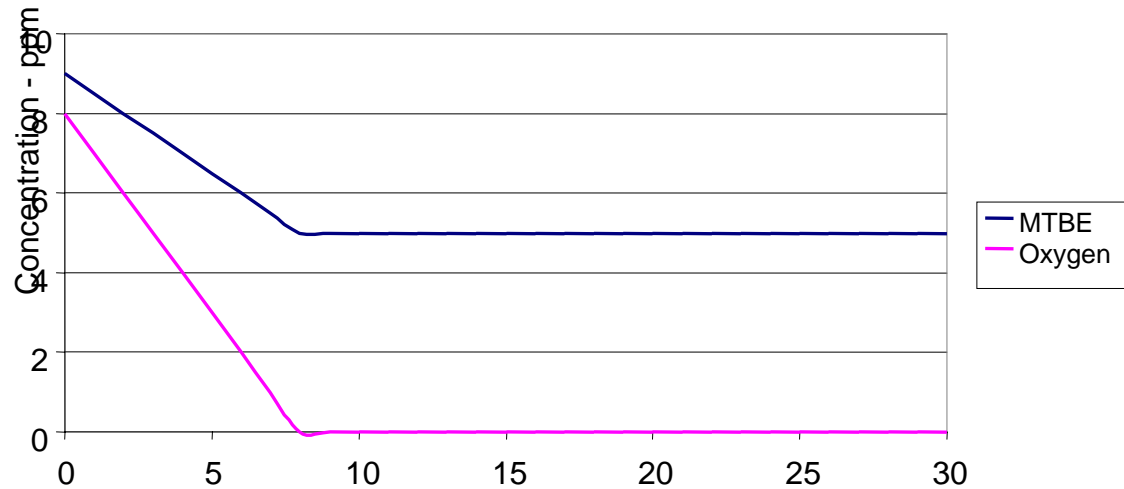
Oxygen Supply    ~8 mg/L if air saturated  
                         ~40 mg/l if pure O<sub>2</sub>  
                         higher with peroxide (H<sub>2</sub>O<sub>2</sub>)

Oxygen Demand – 2.5 x [S] mg/L

[S] = sum degradable constituents  
(TPHg, BTEX, MTBE, TBA)

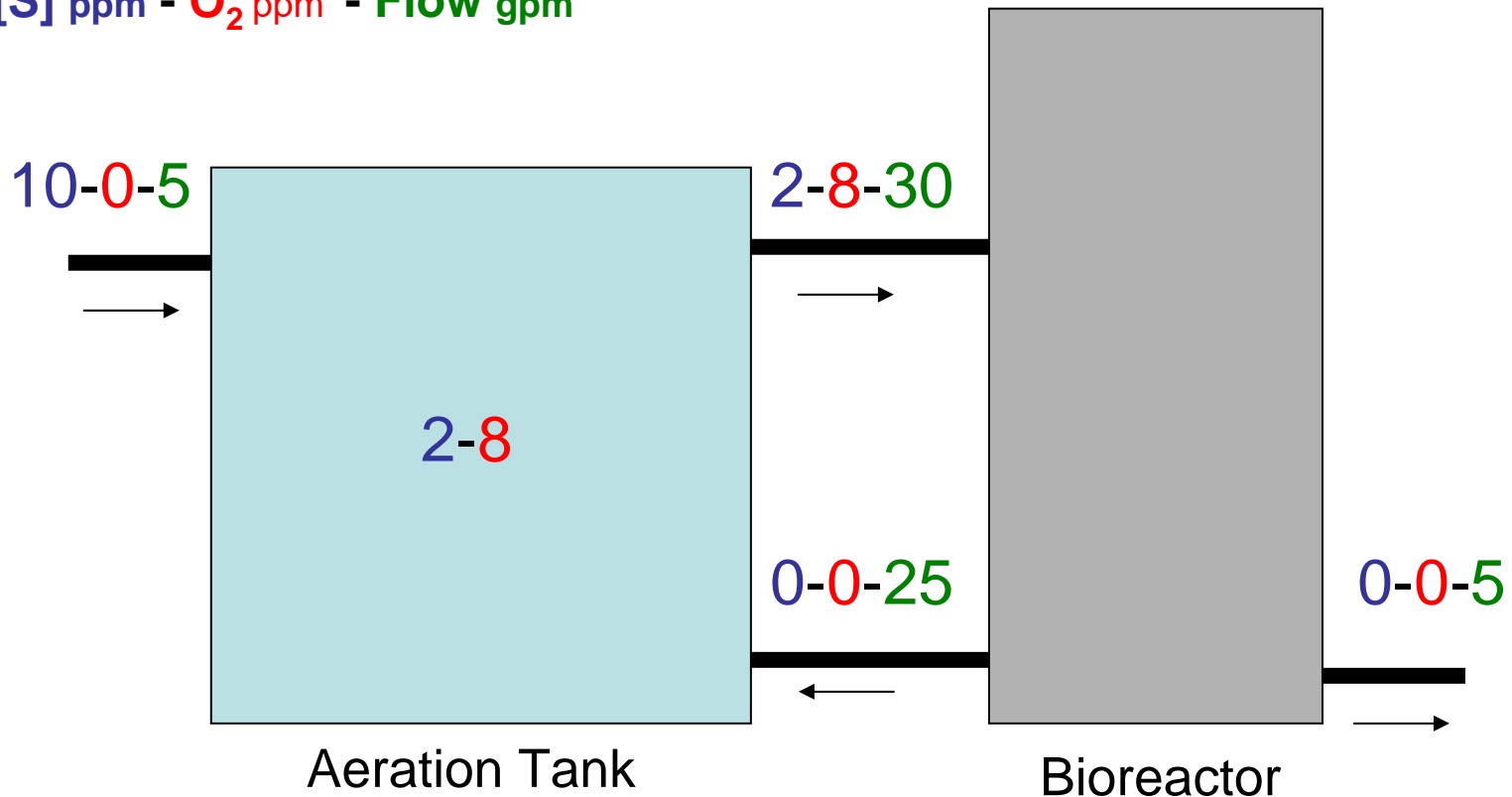
**Need constant or multiple aeration  
if demand exceeds supply**

# Multiple smaller units: Better than one large unit!



# Recycle also reduces O<sub>2</sub> demand

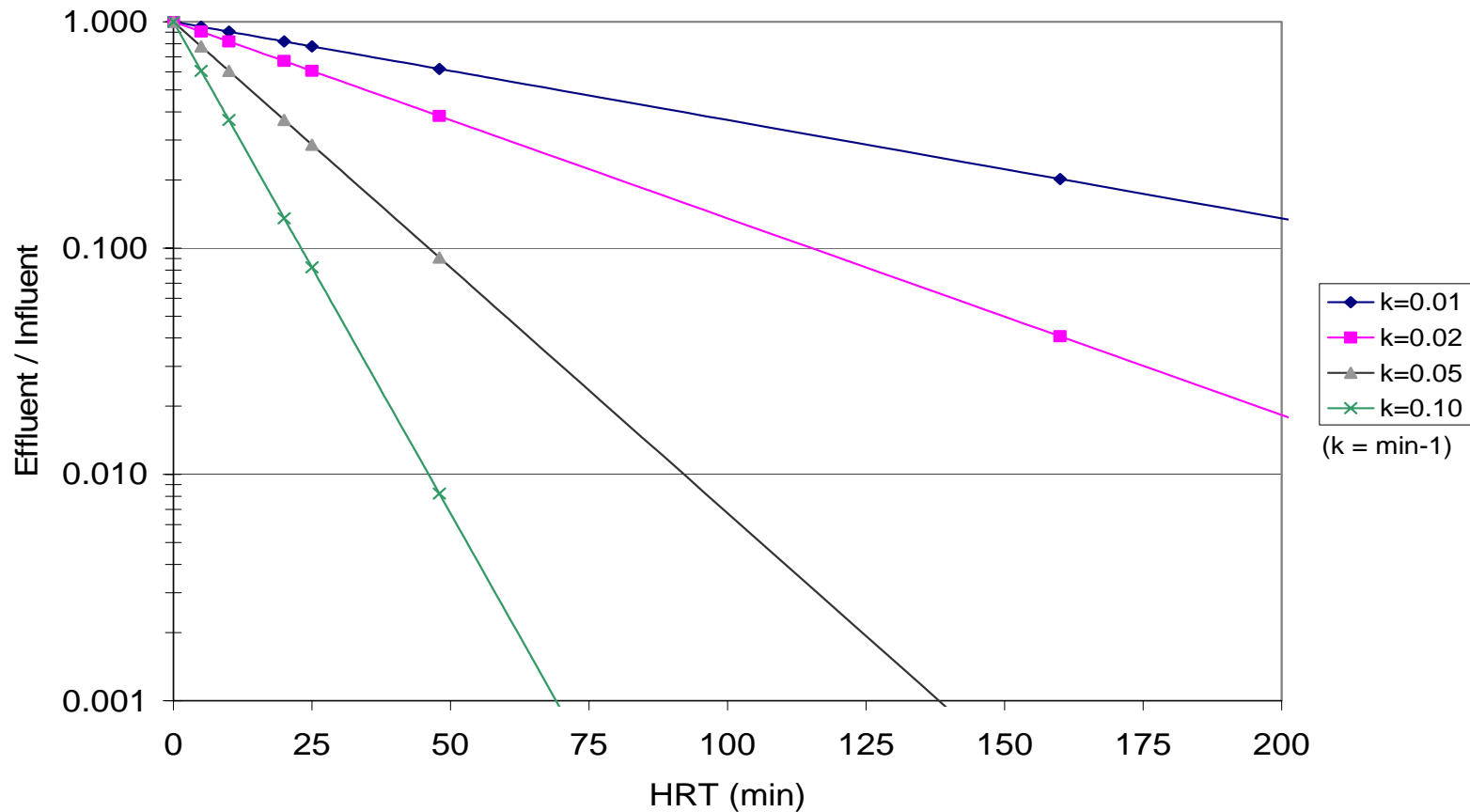
[S] ppm - O<sub>2</sub> ppm - Flow gpm



**Recirculation rate is controlled by the oxygen demand.**

# Impact of degradation rates on hydraulic retention time

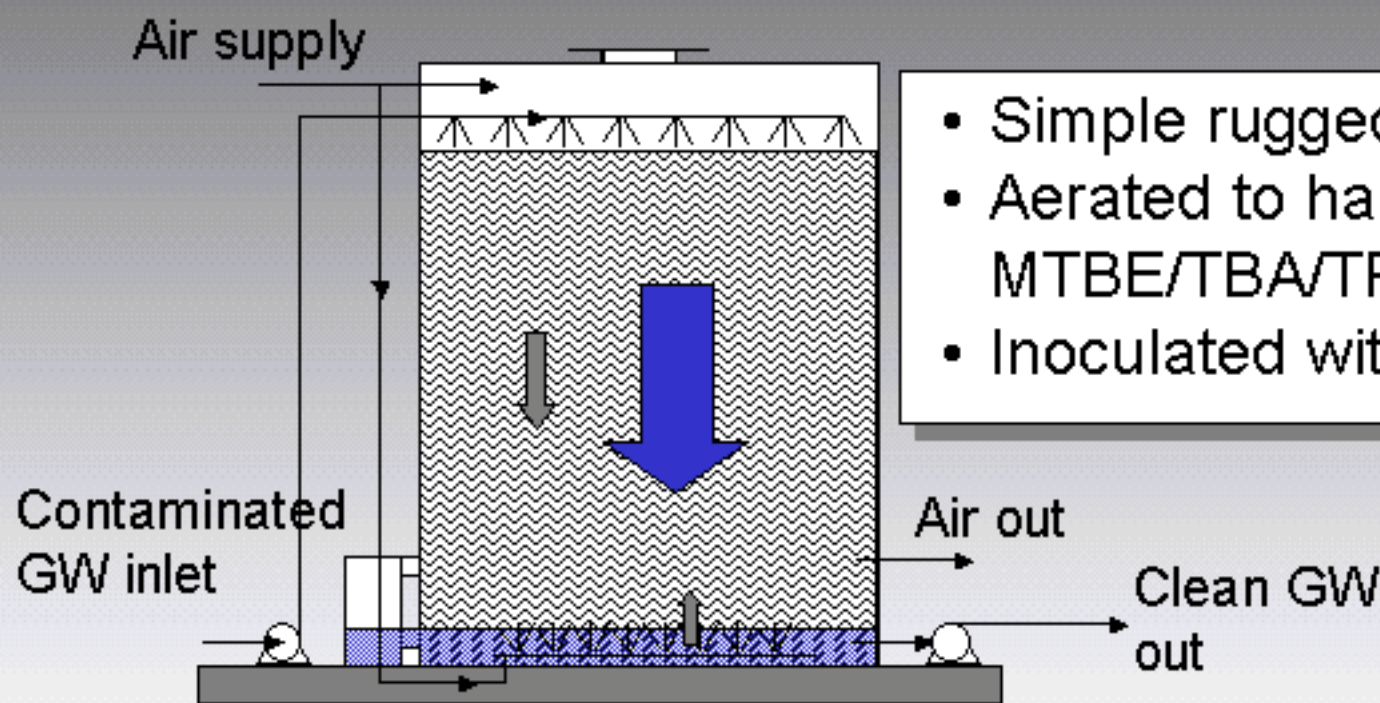
Effluent Concentration as Function of 1st Order Reaction Rate



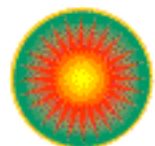
# Fixed-film biotreatment

- Cost-effective - low capital and O&M costs
- Small footprint, need minimal operator attention
- High biomass density & low sludge production
- Minimizes washout of slow-growing organisms
- Capable of handling both hydraulic and organic shock loads
- Treats a variety of contaminants, high-quality effluent produced

# Ex-Situ Trickling Filters for GW Treatment



- Simple rugged design
- Aerated to handle high MTBE/TBA/TPH conc.
- Inoculated with mixed cultures



# Energy Resource Institute Biotrickling filter

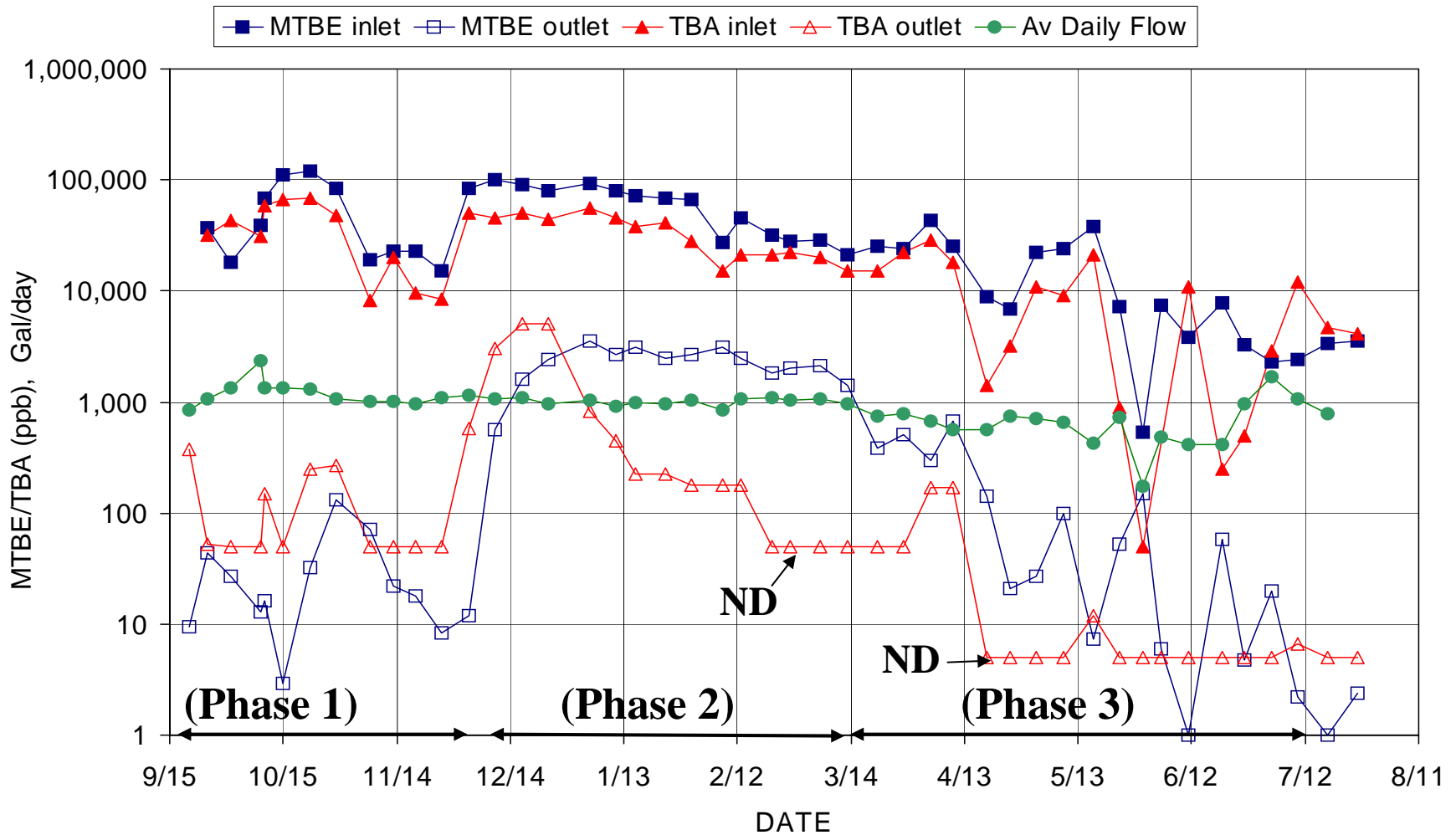


**1,000 gal mobile Unit**  
**\$30,000**  
**2 gpm**  
**20 ppm**

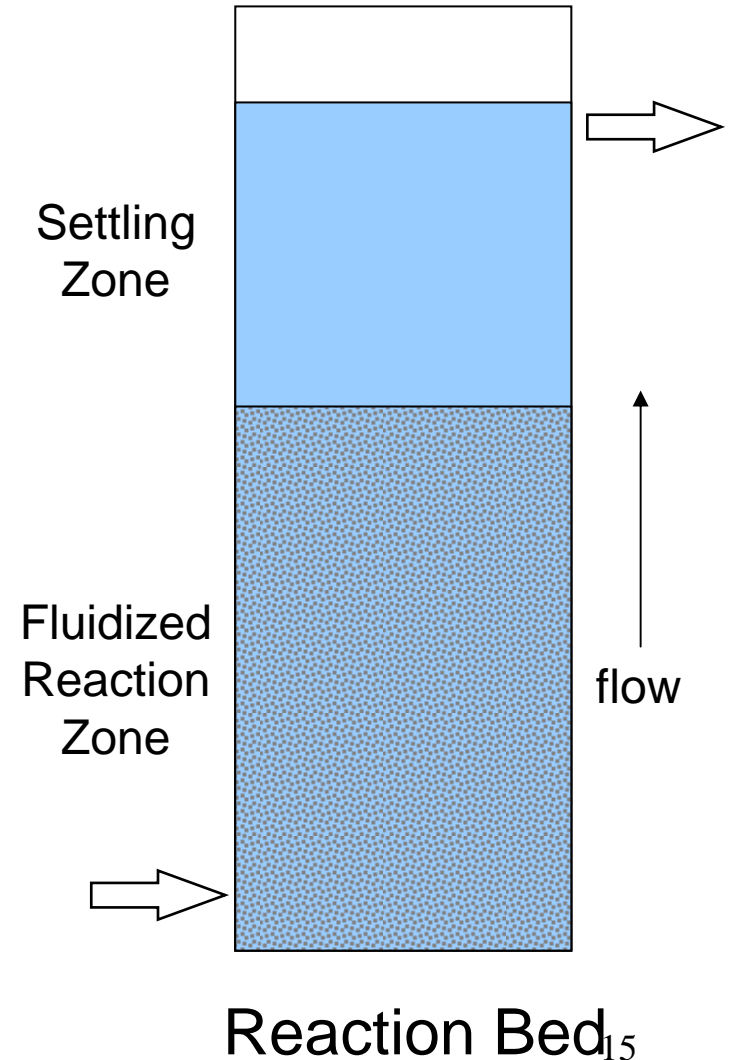
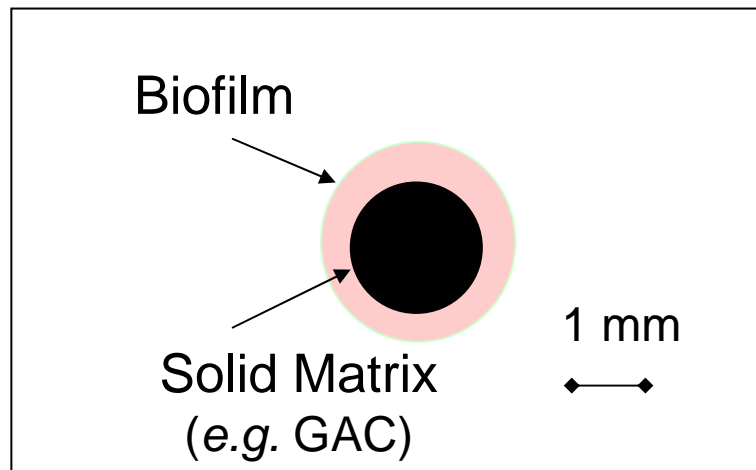
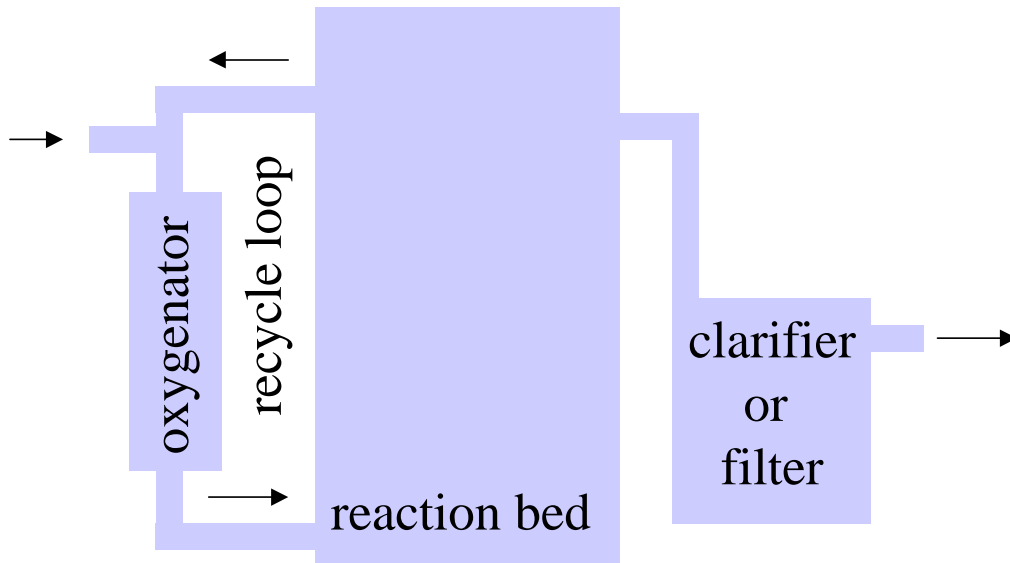


**3,000 gal Unit**  
**\$60,000**  
**5 gpm**  
**50 ppm**

# Energy Resource Institute Biotrickling filter



# Fluidized bed bioreactors



# Environmental Resolutions Inc.

## Fluidized bed bioreactors



**ERI-4000**



**ERI-500**

# Final Report: Development of Biodegradation System for Treatment of Groundwater Impacted by Methyl *Tert*-Butyl Ether

**EPA Contract Number:** 68D00237

**Title:** Development of Biodegradation System for Treatment of Groundwater Impacted by Methyl *Tert*-Butyl Ether (MTBE)

**Investigators:** [O'Connell, Joseph](#)

**Small Business:** [Environmental Resolutions Inc.](#)

**The fluidized bed reactor affords complete mineralization (oxidation to carbon dioxide and water) of both MTBE and TBA from the high values often found at service stations (100,000 µg/L). Concentrations of MTBE and TBA exiting the fluidized bed reactor were below the limits of detectability. In a single pass through the pilot-scale fluidized bed reactor, MTBE concentrations were reduced from 1,300 µg/L to non-detectable at less than 1 µg/L with a residence time of about 15 minutes. TBA concentrations were reduced from 1,300 µg/L to non-detectable at less than 5 µg/L. The use of a recycle loop will allow treatment of incoming concentrations of 200,000 µg/L or more and produce effluent with concentrations less than 5 µg/L.**

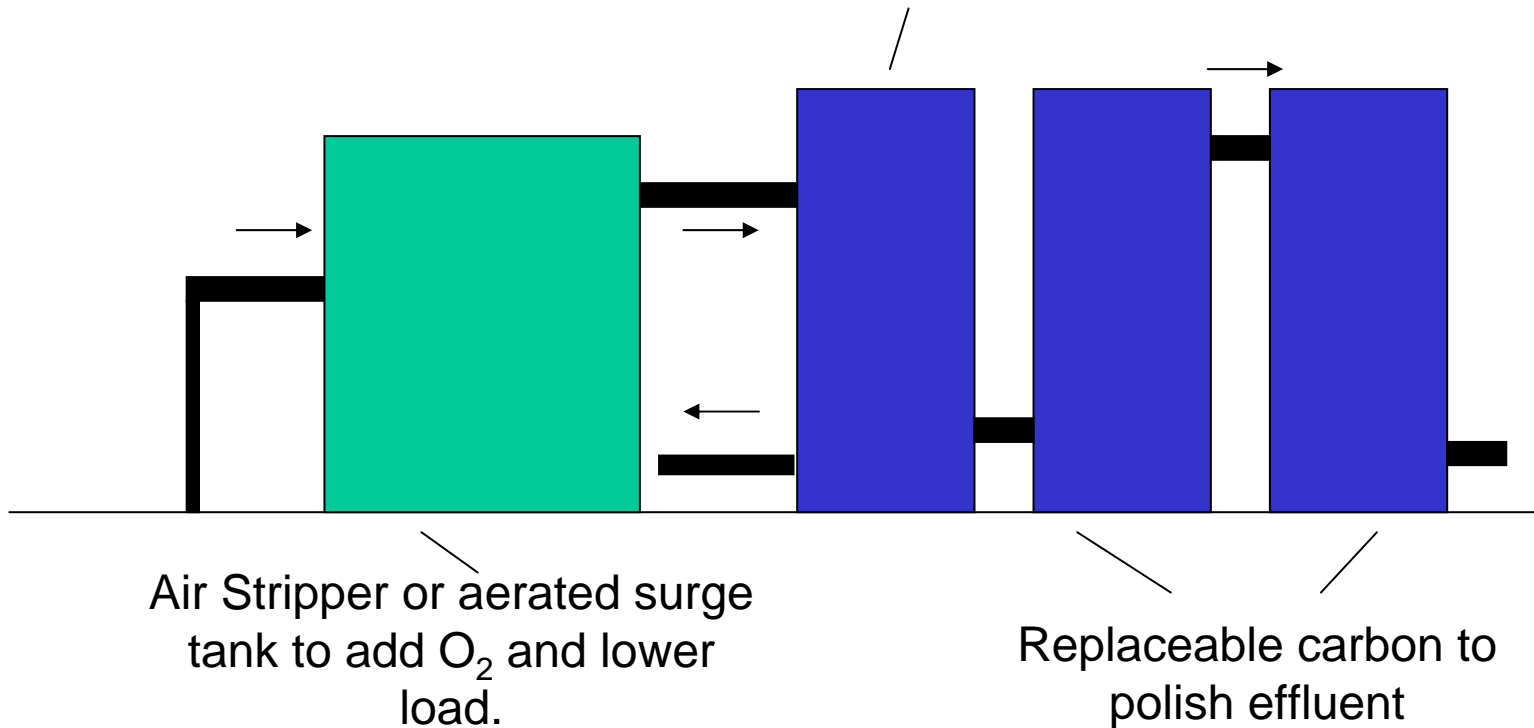
# BioGAC

## Biological Granulated Activated Carbon

- Turning a traditional GAC system into a bioreactor by allowing bacteria to grow on the carbon (*aka* controlled biofouling).
- Keep one carbon canister inline without changing (retains active biomass)
- Add recycle line to increase flexibility
- Oxygen required - Aeration method needed.
- **Inoculation of carbon may speed start-up.**

# A BioGAC system on paper

Keep first canister of carbon to maintain degraders.



# A BioGAC system in the field

6x 1000 lb GAC units in series  
1+ gpm, Sparged Surge Tank



# Shell Global Solutions BioGAC process flow diagram

