Environmental Fluids REU - University of Colorado at Boulder - Summer 2008 Project Presentation

Characterizing Hydrogen Peroxide Degradation By Granular Activated Carbon For Advanced Oxidation Processes In Water Treatment

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Background - Advanced Oxidation Processes (AOPs)

- H_2O_2 is dosed
- $H_2O_2 + h\nu \rightarrow 2(OH^{\bullet})$
- 5-10% of the dosed H_2O_2 is consumed
- Residual H_2O_2 must be removed

Background – Granular Activated Carbon (GAC)

- Removal capability may be influenced by:
  - External mass transfer and fluid velocity
  - Internal mass transfer and GAC particle size
- Carbon packed beds:
  - Empty bed contact time (EBCT)
  - Mass transfer zone and breakthrough
- Sustained performance and competition

Objectives

#1. Characterize mass transfer mechanisms for H_2O_2 removal by GAC – external vs. internal

#2. Characterize the H_2O_2 / GAC surface reaction and mass transfer zone

#3. Investigate performance impact of carbon age and water total organic carbon (TOC) levels

Methods

#1 Jar tests

4 carbon sizes,
High and low mix speeds

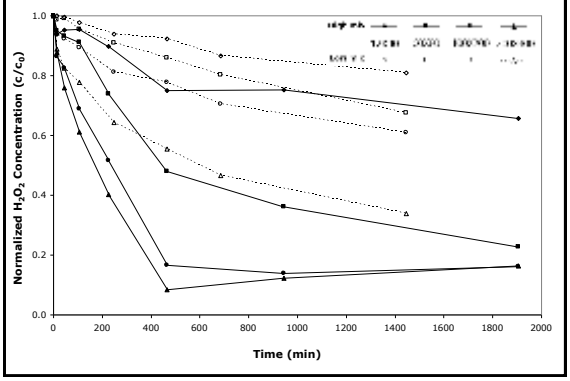
#2 Column test

Mass transfer zone

#3 Jar tests

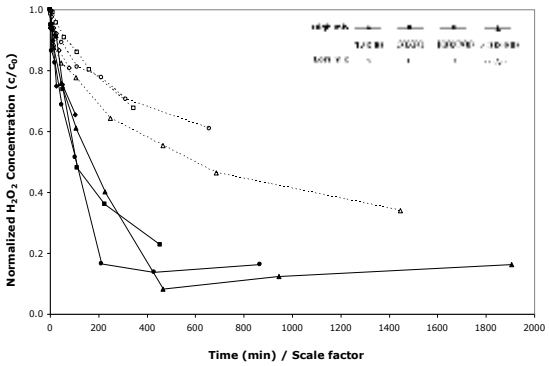
3 carbon ages,
High and low TOC waters

Objective #1 Jar Tests – carbon size and mix speed



Objective #1 Jar Tests – carbon size and mix speed

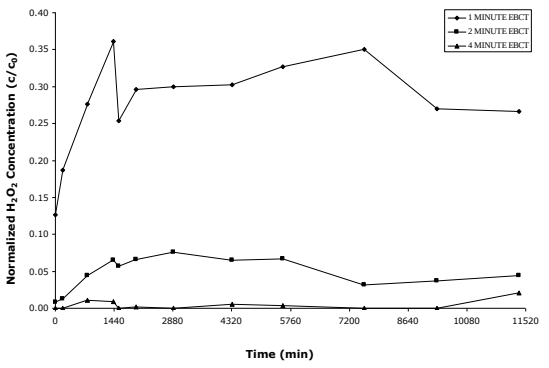
Transformed time scale



RESULTS – Objective #1

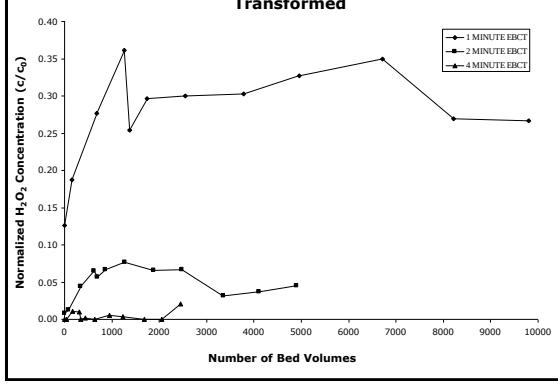
- Smaller GAC particles remove H_2O_2 more rapidly
  - Scale factor reveals the relationship is linear
- Higher fluid velocities improve removal capability

Objective #2 Continuous Flow Column Test



Objective #2 Continuous Flow Column Test

Transformed

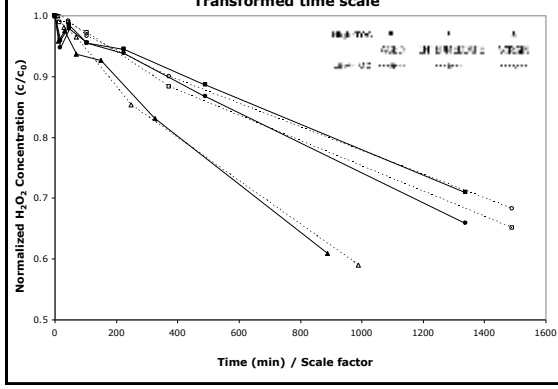


RESULTS – Objective #2

- Effluent concentrations stabilize
- H_2O_2 breakthrough is contained by an EBCT < 4 minutes

Objective #2 Jar Tests – carbon age and water TOC levels

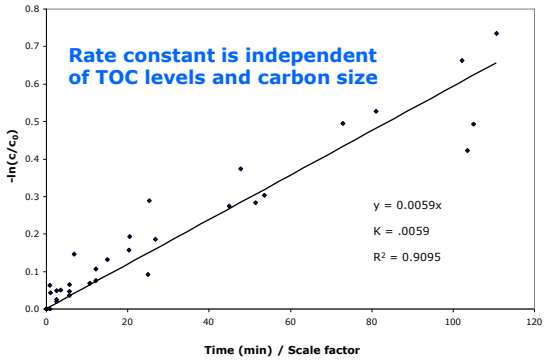
Transformed time scale



RESULTS – Objective #3

- Aged and intermediate carbon demonstrate similar removal kinetics
- Virgin carbon demonstrates significantly better removal kinetics
- TOC, at the levels measured, does not impact removal kinetics

Jar Tests Combined Kinetic Analysis
3 water TOC levels – 4 carbon sizes



Conclusions

#1. Both internal and external mass transfer are significant mechanisms for H_2O_2 removal by GAC

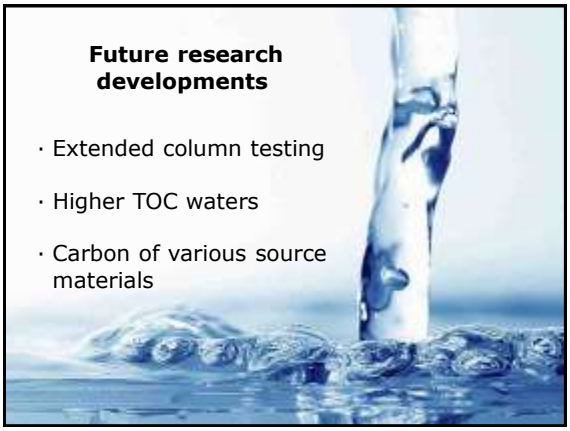
#2. The H_2O_2 surface reaction is observed to be catalytic for the short time measured

#3. Aged carbon removal capability declines from virgin carbon, but to a common level

TOC, at the levels measured, does not impact removal capability

Future research developments

- Extended column testing
- Higher TOC waters
- Carbon of various source materials



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