# Evaluation of Treatment Process Impacts on Microcystin Removal Using Activated Carbon Adsorption

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OTCO Water Workshop

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# Agenda

- WTP process design
- Study purposes
- Challenge study parameters
  - Process simulations
  - Microcystin spike
  - Test procedures
  - Sample prep procedures
- Permanganate results
- Carbon results
- Carbon/coagulant results
- Questions

# Erie County Water Authority (ECWA)

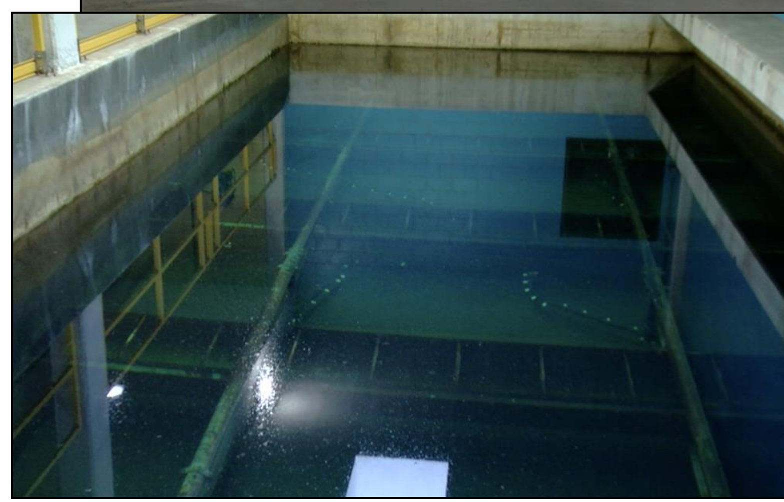
Erie County
Water Authority

Sturgeon Point Water WTP

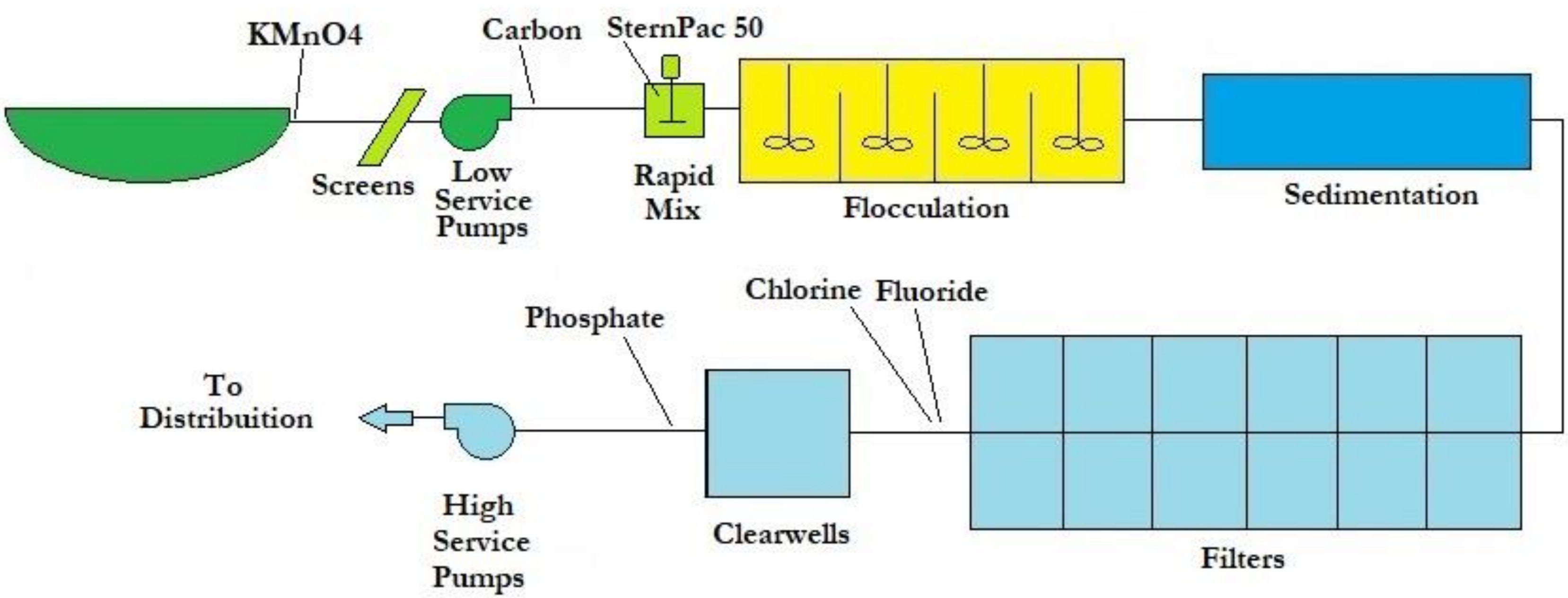
- Two larger surface water plants on Lake Erie
- Van De Water WTP
  - Niagara River source
  - 20 mgd average
- Sturgeon Point WTP
  - Lake Erie source
  - 50 mgd average

# Erie County Water Authority (ECWA)

- Screening
- Pre-oxidation
- Activated carbon adsorption
- Coagulation
- Flocculation/sedimentation
- Filtration
- Disinfection
- Fluoridation
- Corrosion control



# Erie County Water Authority (ECWA)



# Erie County Water Authority (ECWA)

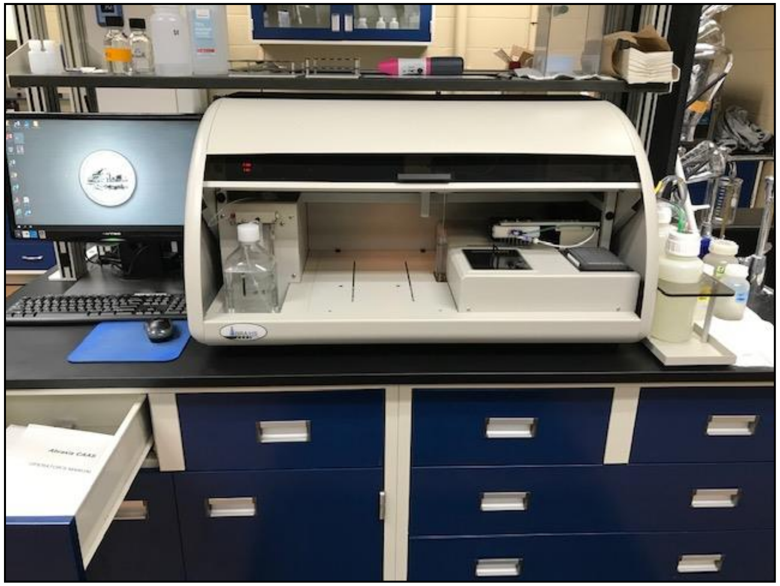
- Purposes for study
  - Simulation Sturgeon Point operations for microcystin reduction capabilities at normal summer flow rate
  - Define applicable microcystin spike concentration
  - Identify impact of pre-oxidation on microcystin removal at current dosing
  - Identify microcystin removal by pre-selected activated carbon treatment
  - Determine any impacts from coagulant feed on carbon adsorption efficiency
  - Apply findings to the current ECWA HAB Preparedness Program

# Challenge Study Parameters

- Simulate Sturgeon Point treatment at 60 mgd
  - Process detention times
  - Mixing intensities
  - Dosages
  - Flow through velocities
  - Particle settling velocities
- Two rounds of testing
  - Carbon alone
  - Combined carbon and coagulant
- Vary activated carbon dosing (client determined)
  - 10 mg/L, 25 mg/L, 40 mg/L, 60 mg/L

# Challenge Study Parameters

- Microcystin spike level
  - No regulations for microcystins in New York state
  - Ohio experience with microcystins studies and regulatory framework
  - Toledo, Ohio HAB experience 2004 at 58 µg/L
  - Use Ohio EPA challenge testing protocol and spike concentrations
  - ELISA ADDA method for microcystins



Abraxis ELISA ADDA unit

# Challenge Study Parameters

- Microcystin concentrate
  - Algae-laden reservoir source in Northern Ohio (algae harvesting)
  - Numerous freeze-thaw periods to lyse cells
  - Initial analysis of concentrate
    - 3,510 µg/L total microcystin
  - Dark green color with some turbidity
    - TOC level about 4.7 mg/L
  - Used for microcystin sample spiking and challenge testing


Microcystin Concentrate

# Challenge Study Parameters

- Potassium permanganate
  - Pre-oxidation dosing at about 0.8 mg/L
    - No residual data provided
  - Added to intake structure with about **16 minutes** detention time at 60 mgd flow rate
  - Cursory assessment of permanganate oxidation and microcystin reduction
    - Two rounds of testing

# Challenge Study Parameters

- Activated carbon
  - Pre-selected for challenge testing based on previous treatment study results
    - AquaSorb CB-1-MW
    - NSF 61 compliant
  - Blended bituminous/coconut raw materials
    - High iodine number 1,062 mg/g
    - High mesopore volume (transport)
    - High micropore volume (adsorption)
  - Manufactured by Jacobi Carbons

AquaSorb CB-1-MW

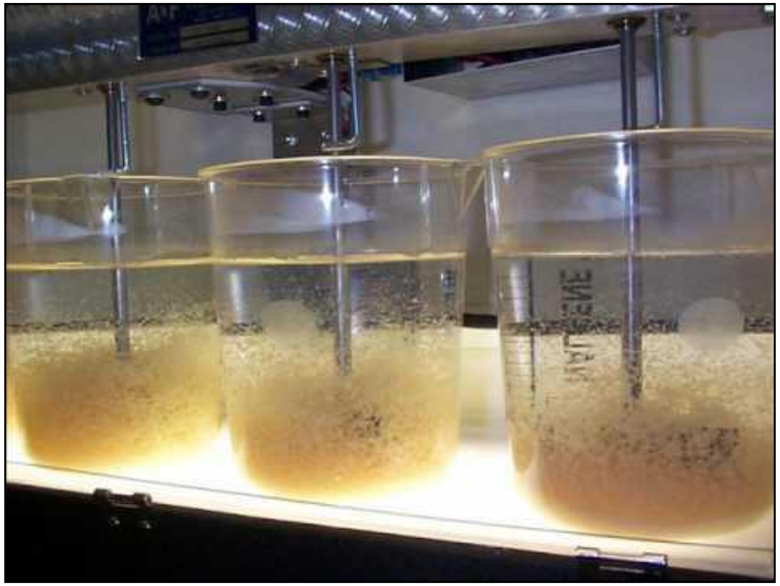
# Challenge Study Parameters

- Activated carbon adsorption times
  - Mixed solution stirred for 60 minutes to displace air from pores
    - Oxygen blinds micropores from adsorption
  - Applied at raw water piping in Low Service Pumping Station
    - **6 minutes** detention time before rapid mix and coagulant addition
    - Additional **40 minutes** contact time in flocculation
    - Additional **138 minutes** potential contact time in sedimentation

AquaSorb CB-1-MW

# Challenge Study Parameters

- SternPac 50 Liquid Coagulant
  - Applied at rapid mix basins
    - Average 12 mg/L wet weight dosage
    - About 5 mg/L dry weight basis
  - Flocculation to form settleable particles
  - Solids settled in sedimentation basins
    - 0.64 gpm/ft$^2$ SOR
  - Dilute solution stirred until homogenous
    - Polyaluminum chlorosulfate (PACS) coagulant



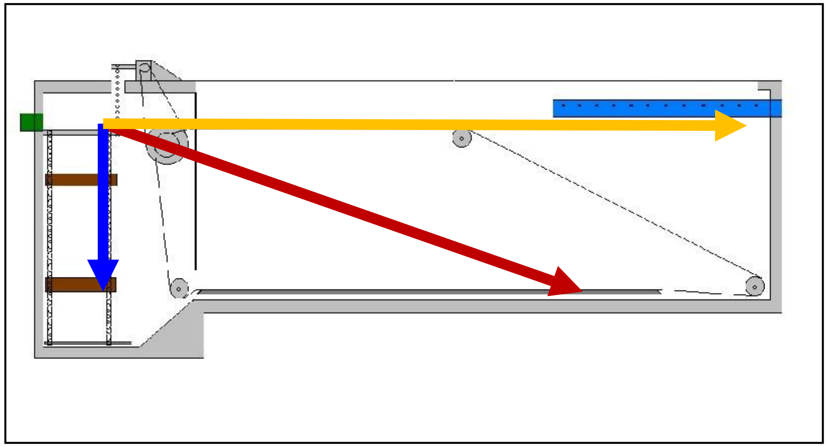
# Challenge Study Parameters

- Flocculation treatment
  - Detention time **40 minutes** at 60 mgd
  - G values assumed to be 40 $sec^{-1}$
    - No flocculator data given
    - Number stages not given
    - Optimal mixing intensity not determined
  - Flocculation treatment applied
    - Carbon treatment only
    - Combined carbon/coagulant

ECWA Flocculators

# Challenge Study Parameters

- Sedimentation treatment
  - Detention time **138 minutes** at 60 mgd
  - Particle settling and flow through velocities used to gauge flow through basins and correlate likely carbon contact time
    - Adsorption likely still occurs while carbon is moving through the water
    - Adsorption likely stops once carbon reaches sludge zone
    - Keep carbon suspended until particle settling rate achieved, then normal settling at 0.64 gpm/$ft^2$



Impact of particle settling velocity on sedimentation

# Challenge Study Parameters

- Particle setting velocity

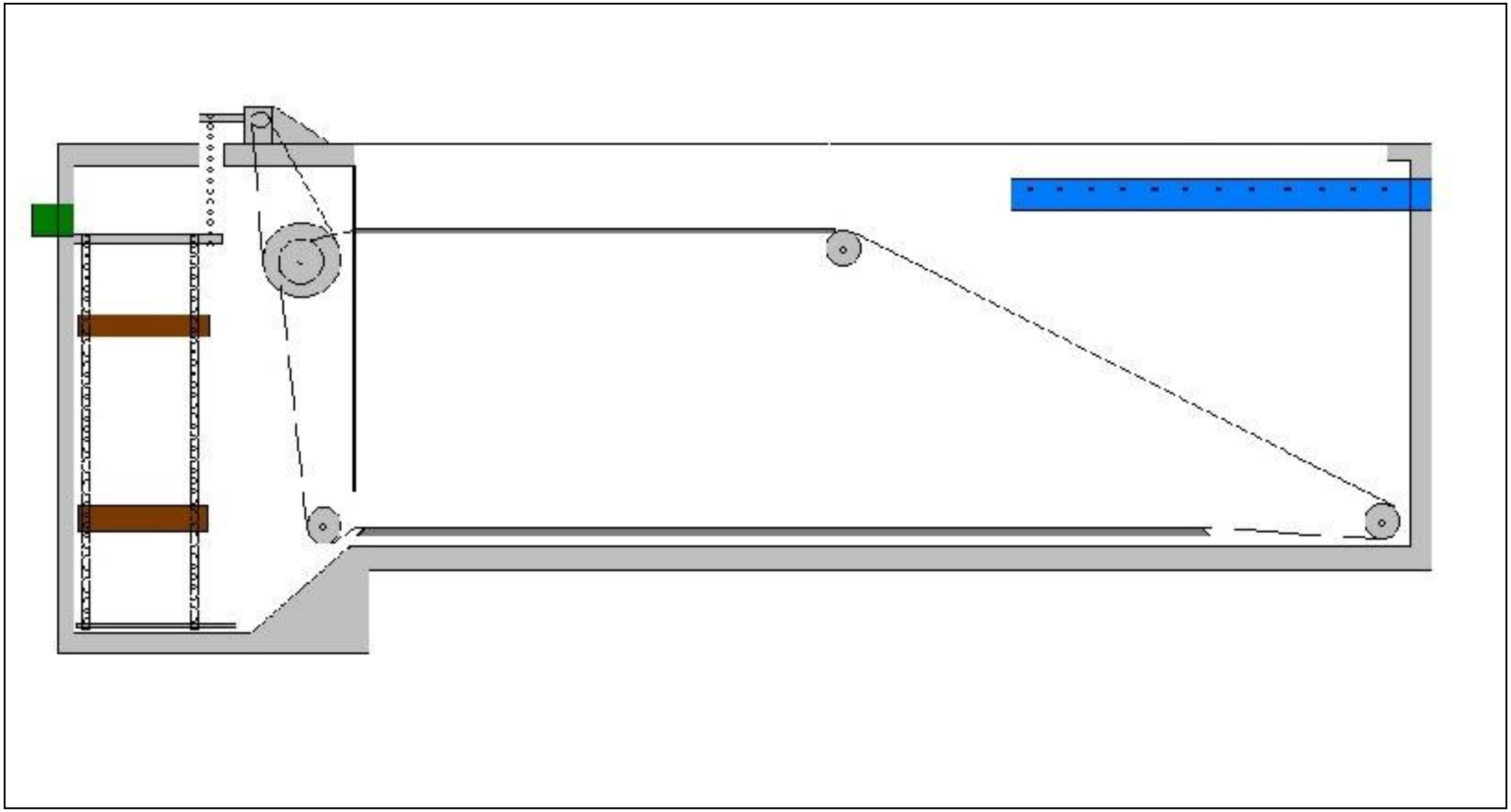
$$\frac{(g * (\rho d - wd) * \rho s^2)}{((18 * \mu k) * 60)} = Settling\ velocity\ (Sv)$$

$$Re = \frac{(\rho s * \left(\frac{Sv}{60}\right))}{\mu k} > 1, drag\ coefficient\ adjustment$$

$$g = gravtational\ constant$$
$$\rho d = density\ of\ particle$$
$$wd = density\ of\ water$$
$$\rho s = particle\ size$$
$$\mu k = kinematic\ viscocity$$
$$Re = Reynolds\ number$$

# Challenge Study Parameters

- Settling velocity impacts



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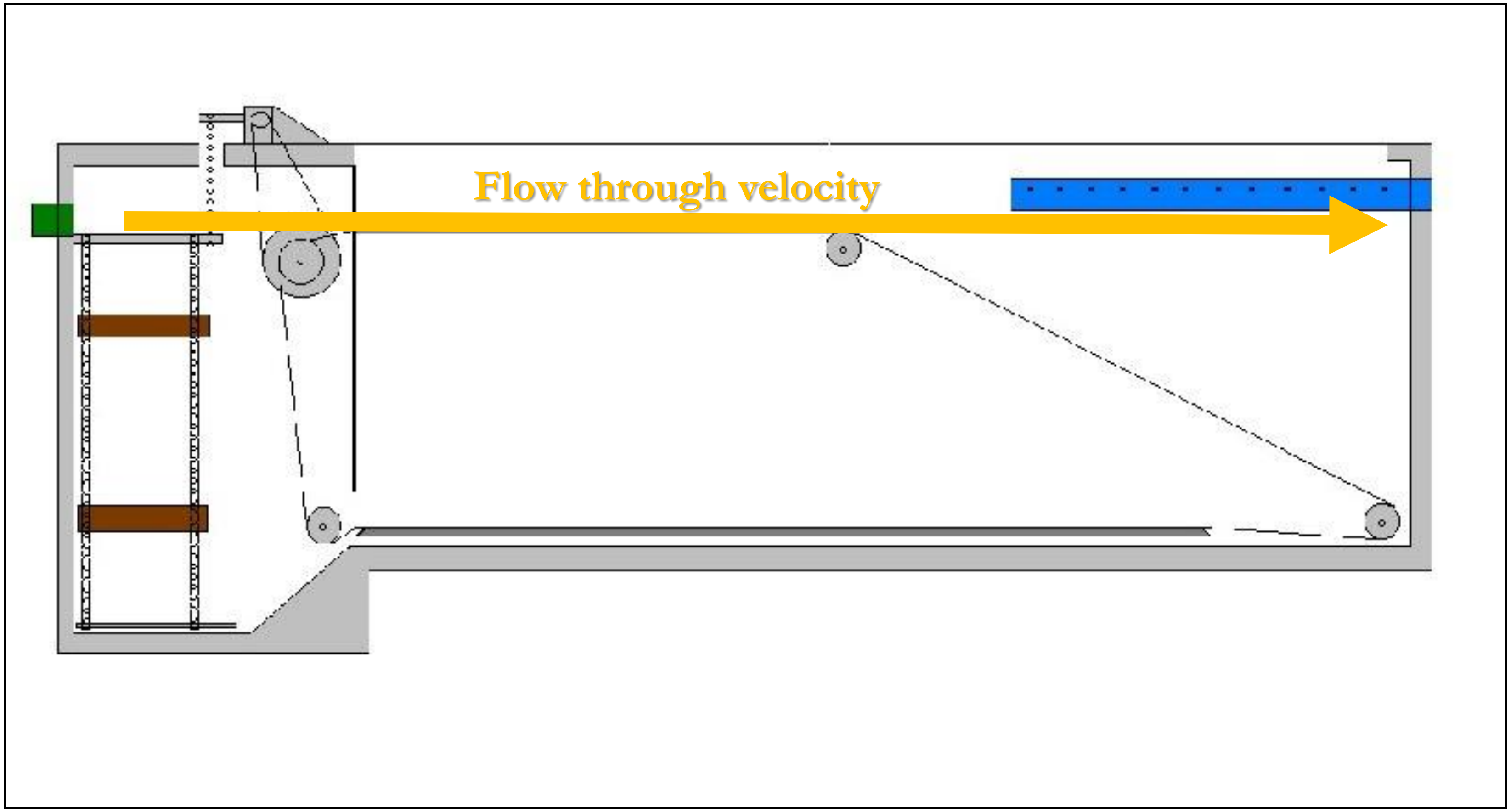

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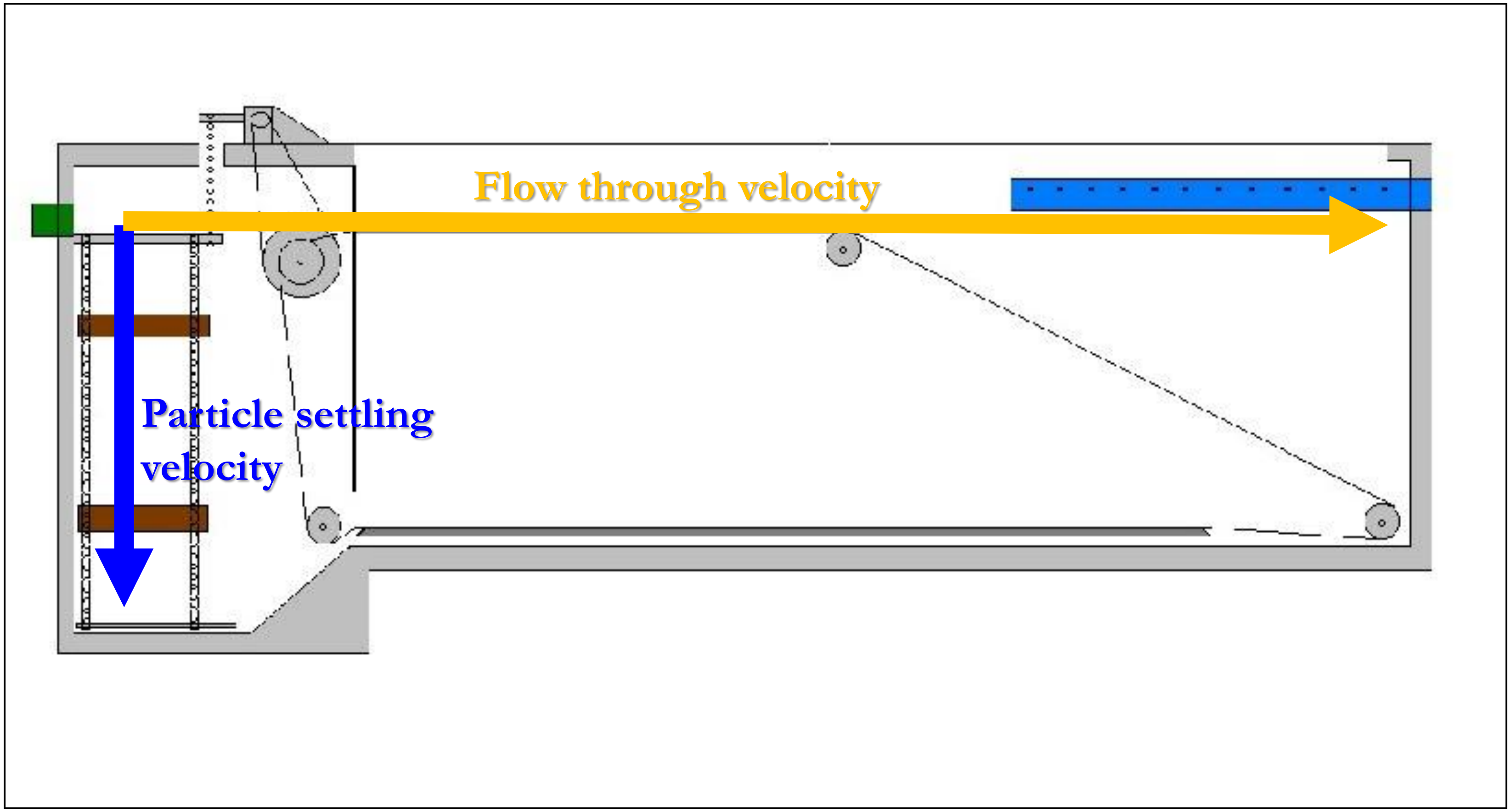
- Sedimentation treatment



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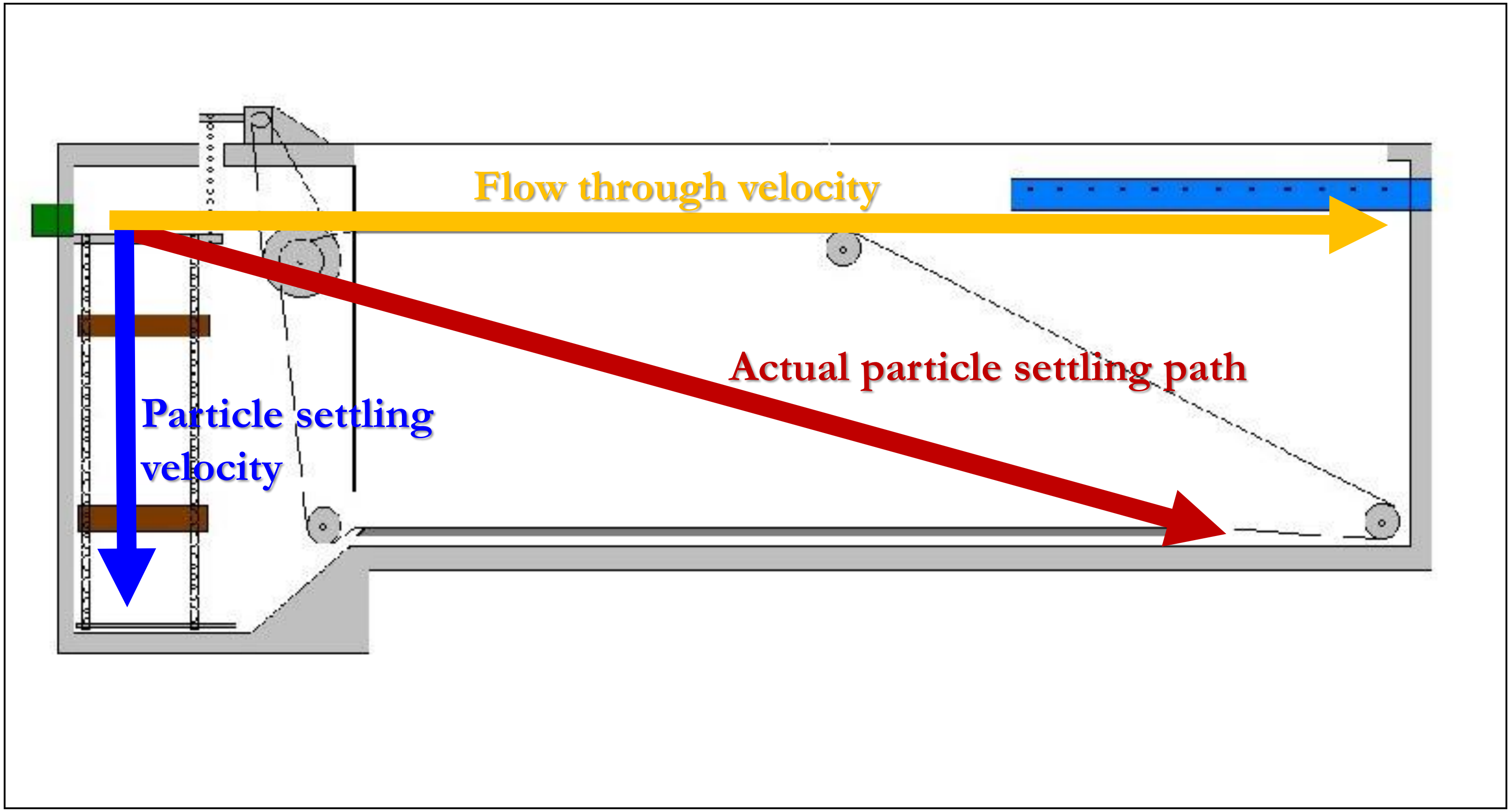

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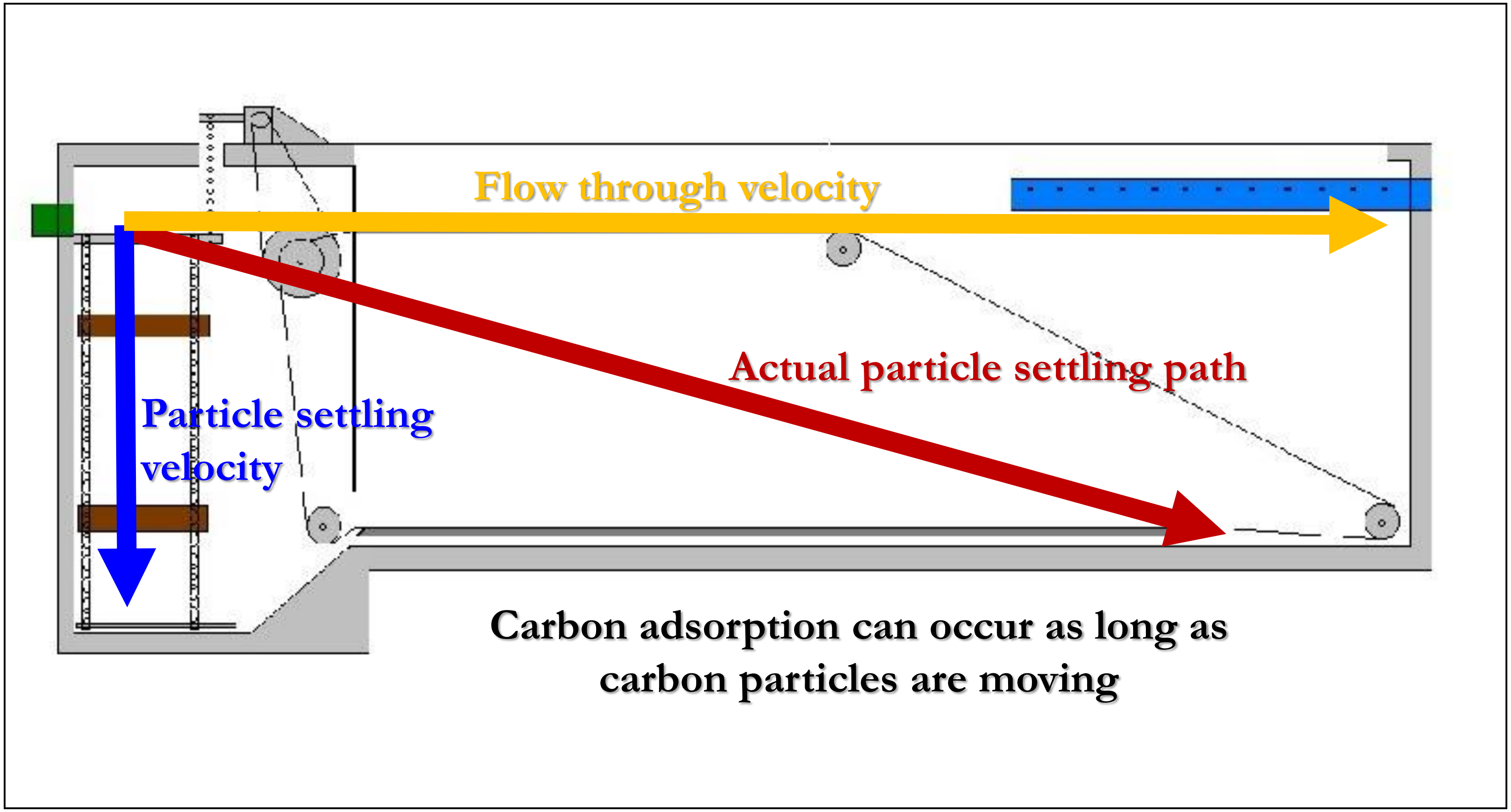
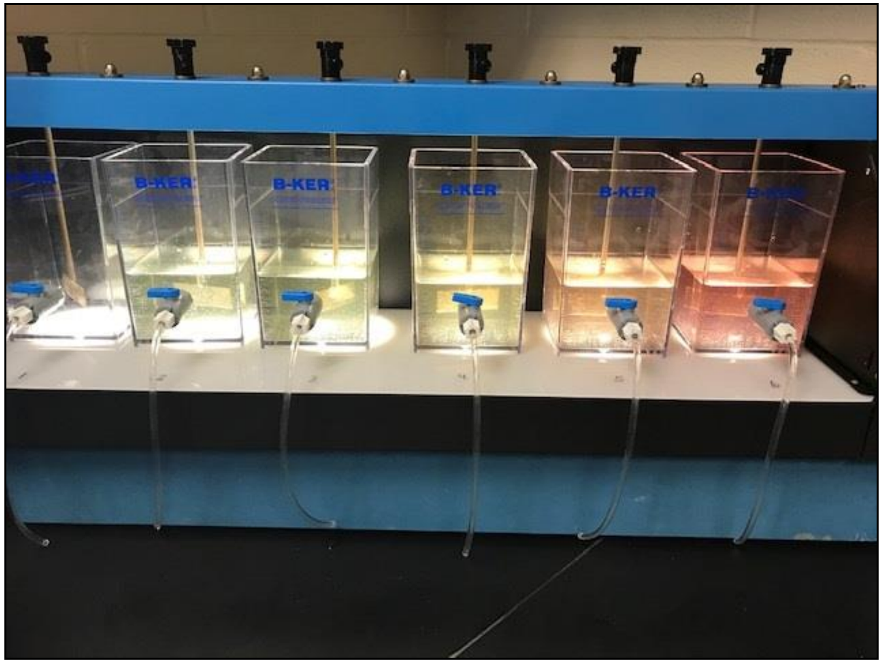


# Challenge Study Procedures

- Microcystin Spike
  - Simple dilution equation based on concentrate level
    - C1V1=C2V2
  - Target 50 µg/L
  - Actual 47.2 µg/L when analyzed
    - ELISA ADDA accuracy, dilution accuracy, viability of concentrate solution
  - Mixed for 10 minutes until homogenous

# Challenge Study Procedures

- Permanganate Oxidation
  - Customary dosage 0.8 mg/L at intake
  - Mixed at 66 rpm for 16 minutes to simulate turbulence and detention in raw water piping to LSPS
  - Samples collected and mixed 1 mL sodium thiosulfate to stop oxidation reaction
  - Diluted to meet 5 µg/L testing limit
  - Refrigerated to lab

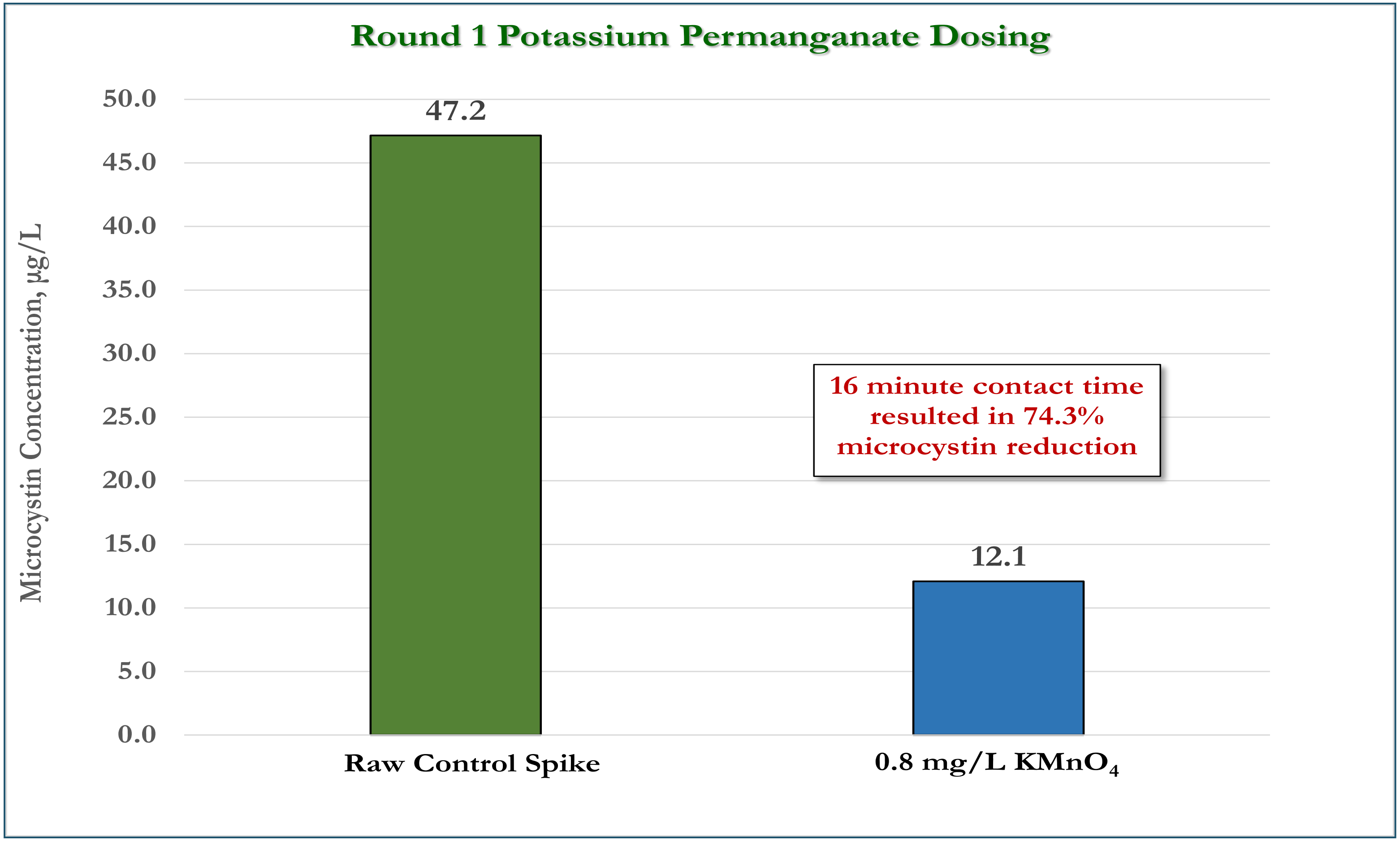


# Challenge Study Procedures

- Carbon Adsorption
  - Dosed as planned from 10 mg/L to 60 mg/L
    - **6 minutes** simulation from LSPS to treatment
    - **40 minutes** rapid mixing and flocculation
    - **138 minutes** sedimentation
  - Samples collected and prepared for lab at each segment
  - Thiosulfate added like oxidized samples
  - Refrigerated to lab

# Challenge Study Results

- Permanganate Oxidation



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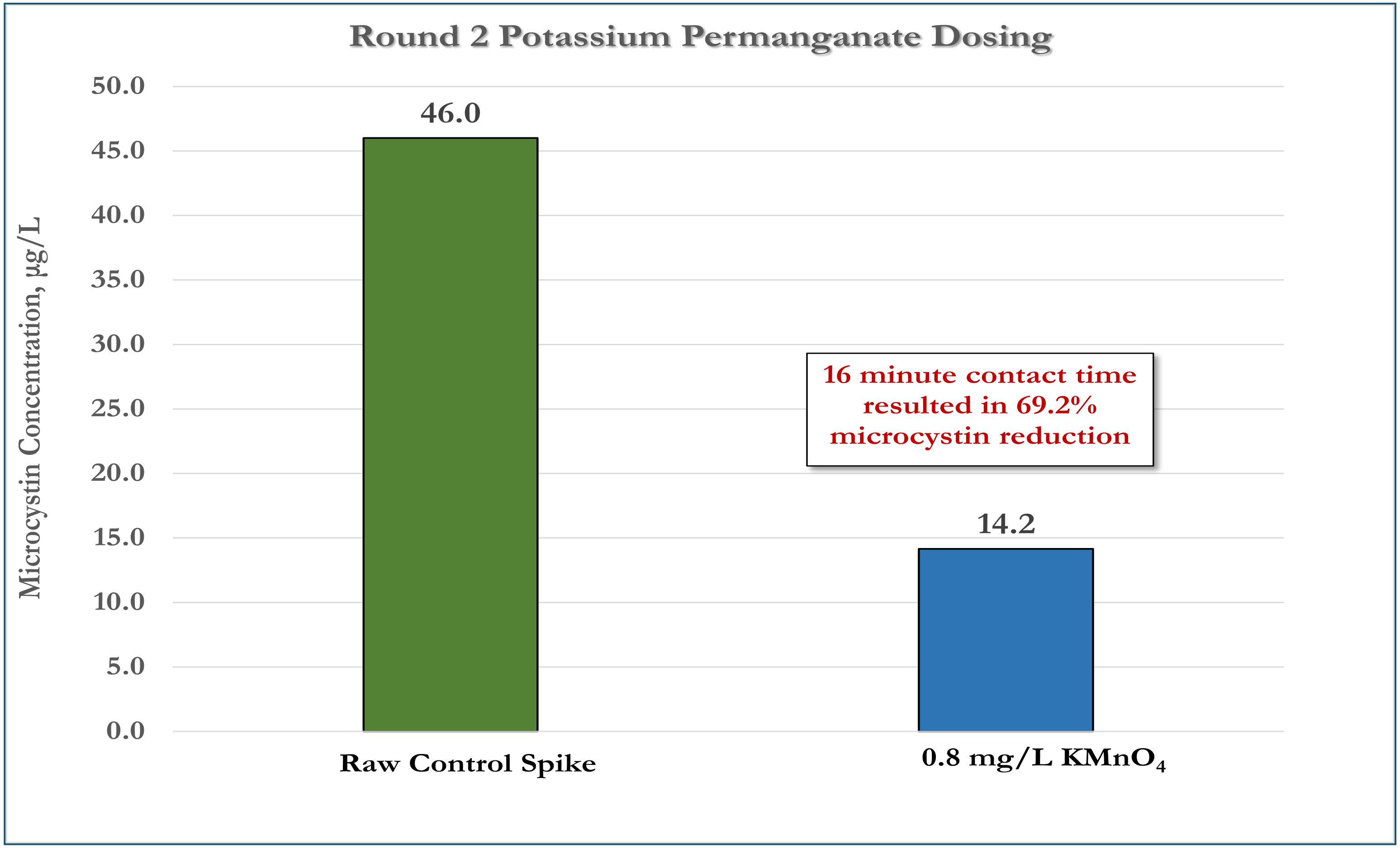
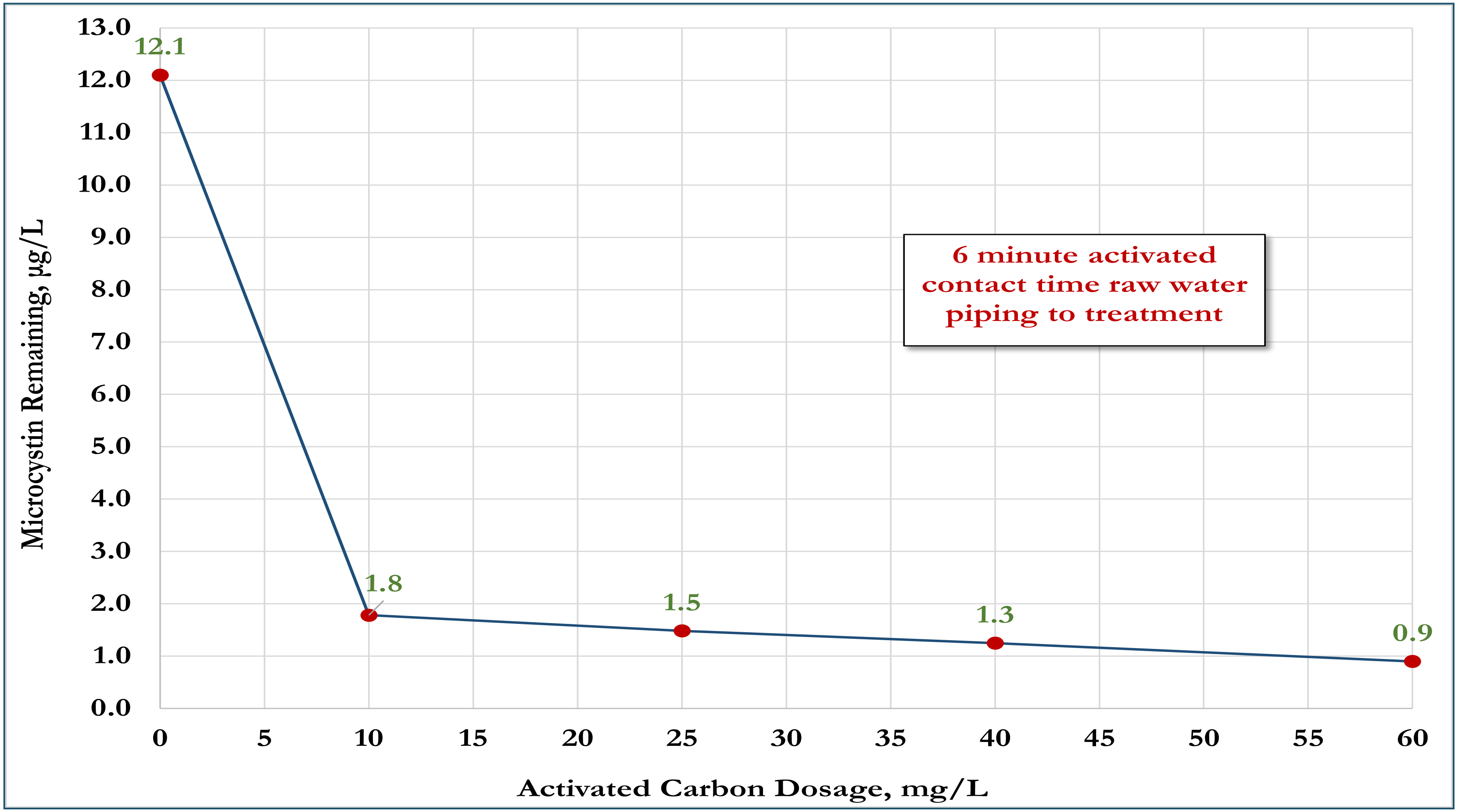


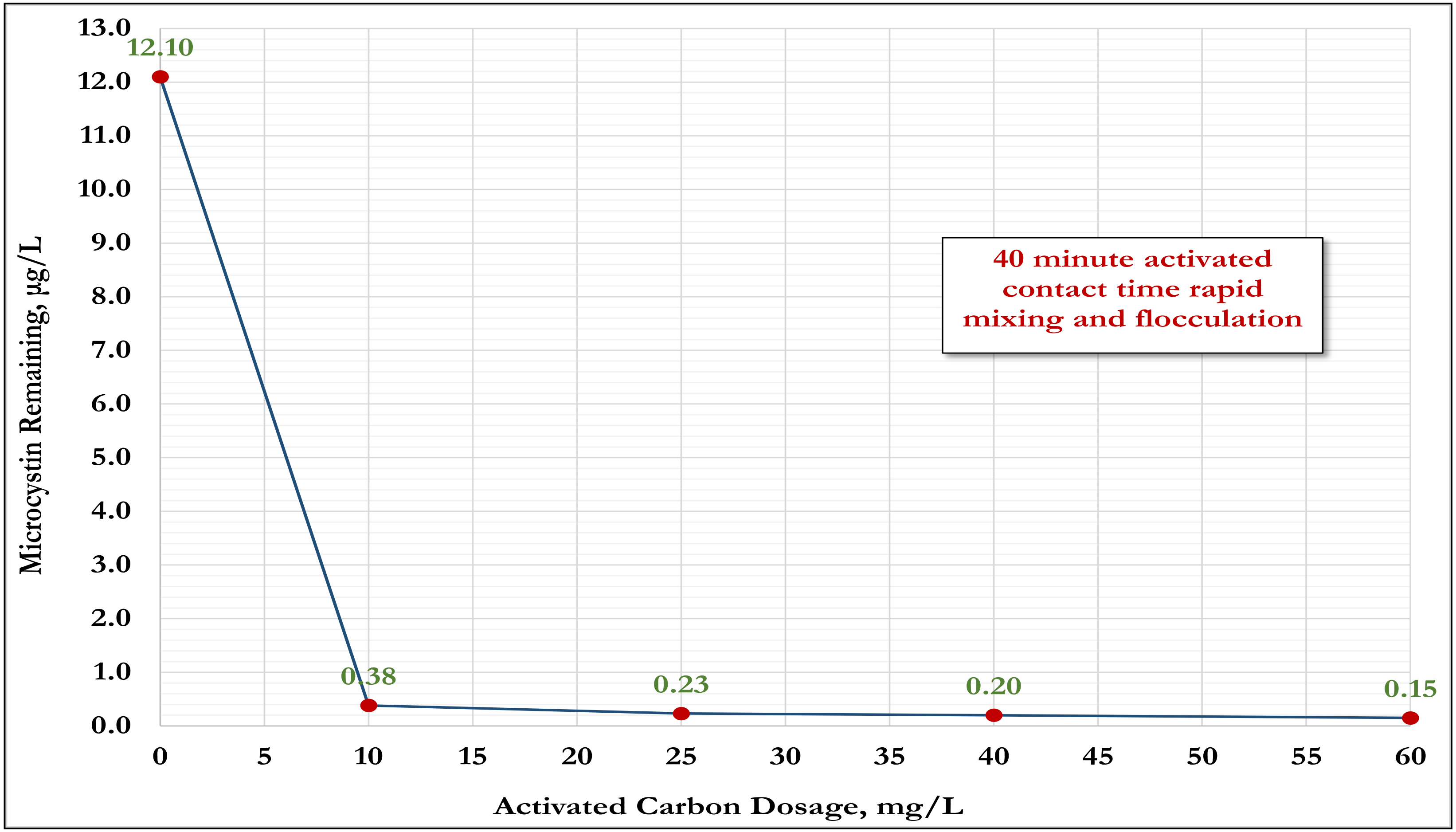
# Challenge Study Results

- Carbon Adsorption – raw water piping (round 1)



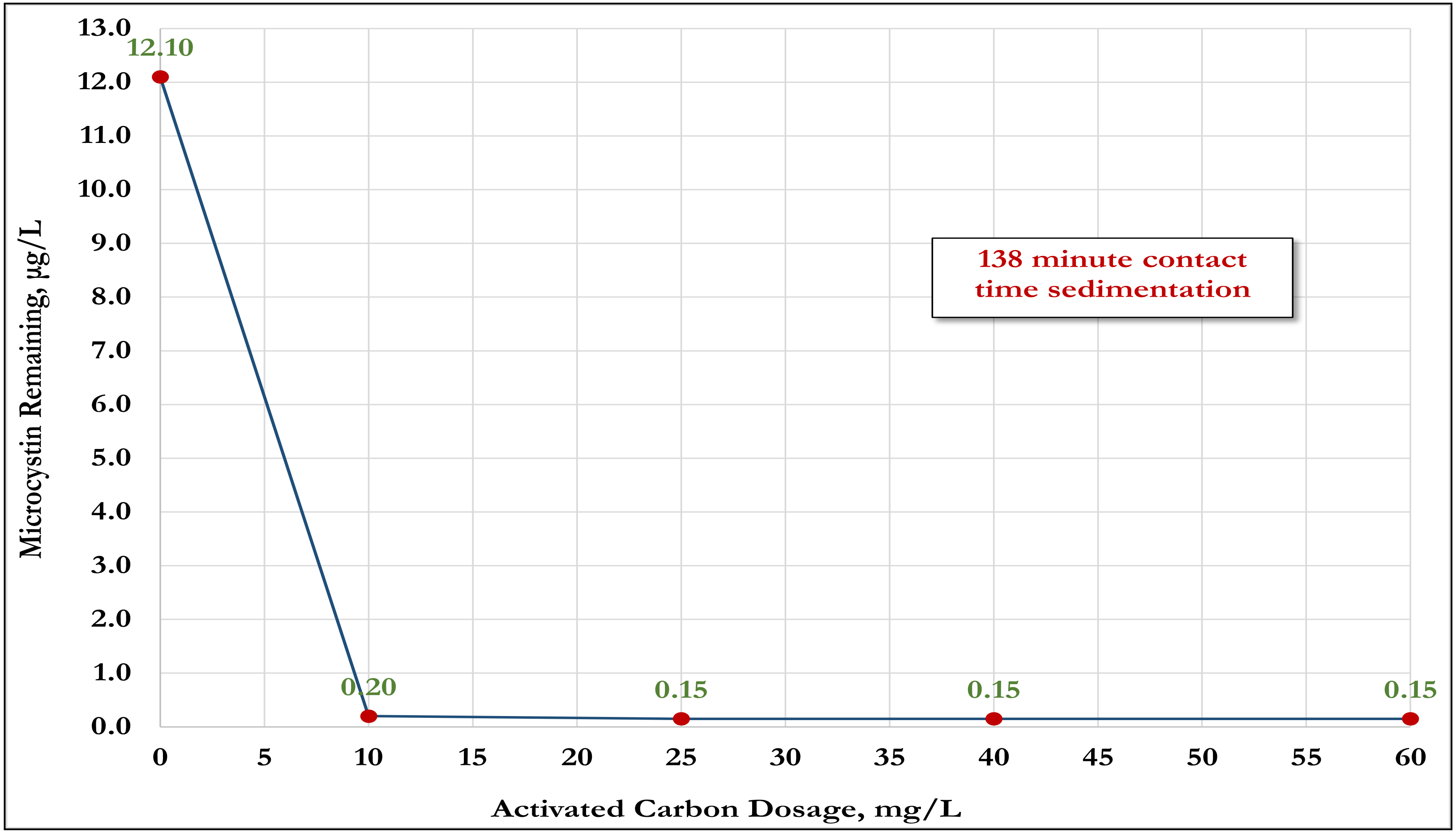
# Challenge Study Results

- Carbon Adsorption – rapid mix/flocculation (round 1)



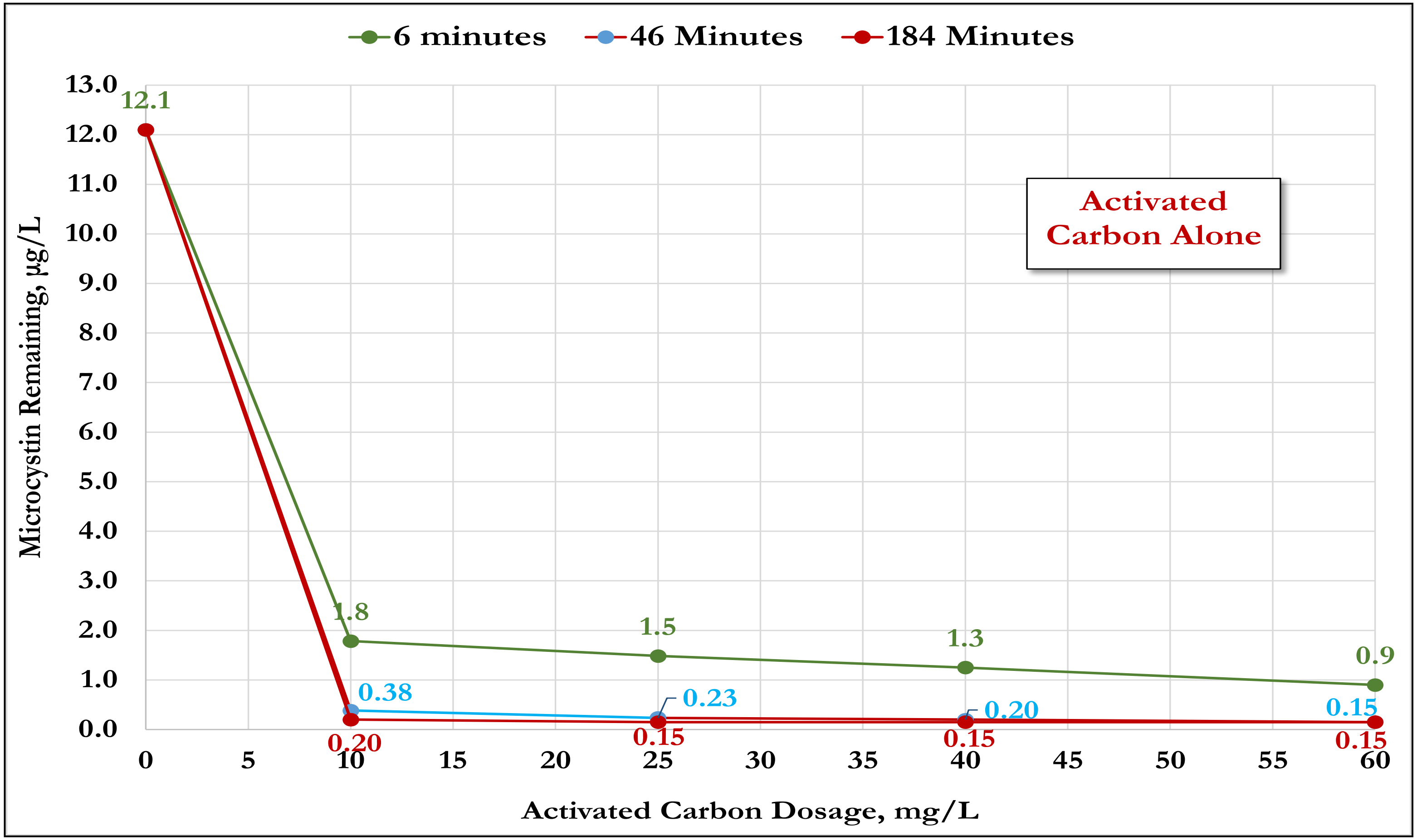
# Challenge Study Results

- Carbon Adsorption – sedimentation (round 1)



# Challenge Study Results

- Carbon Adsorption – combined treatments (round 1)



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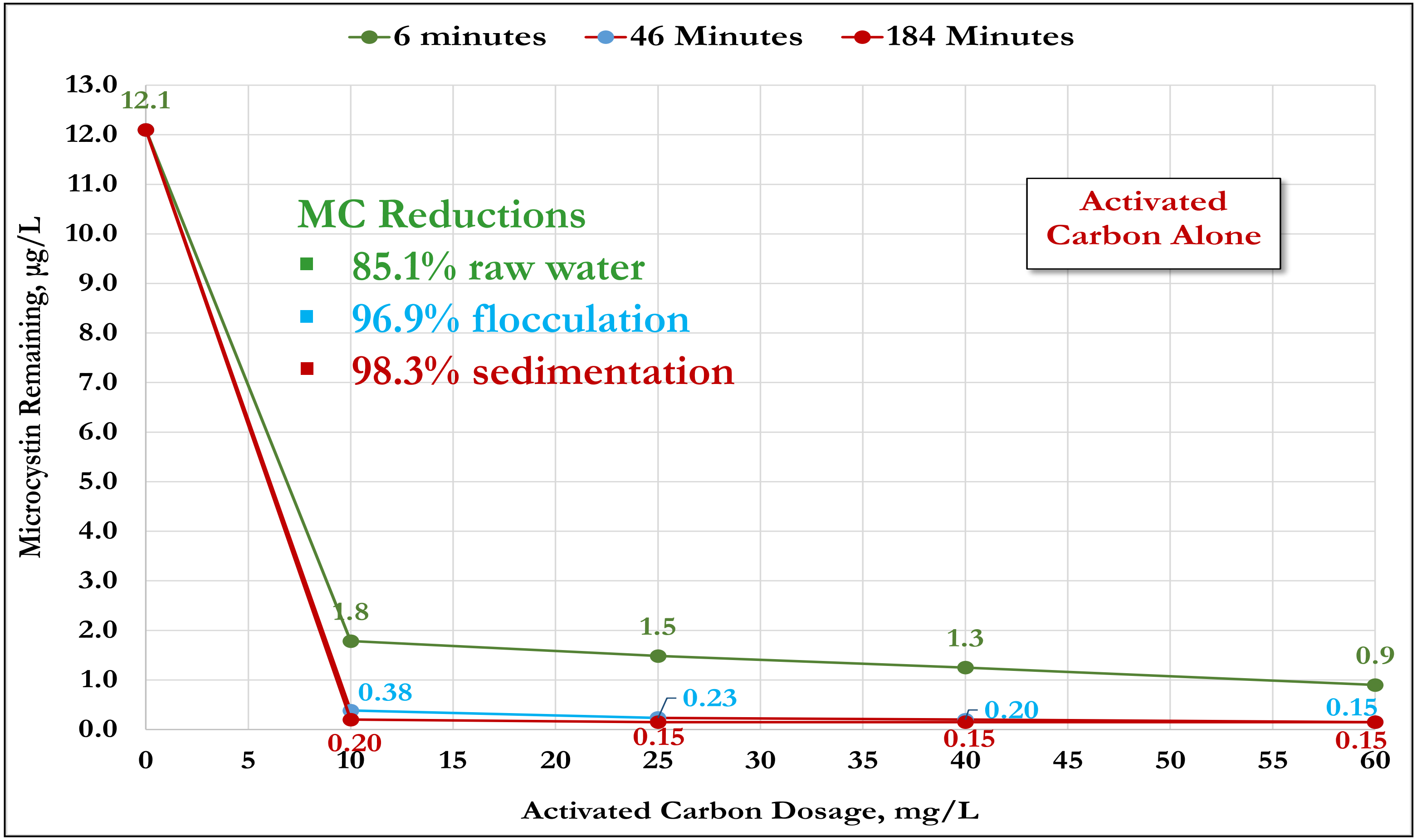

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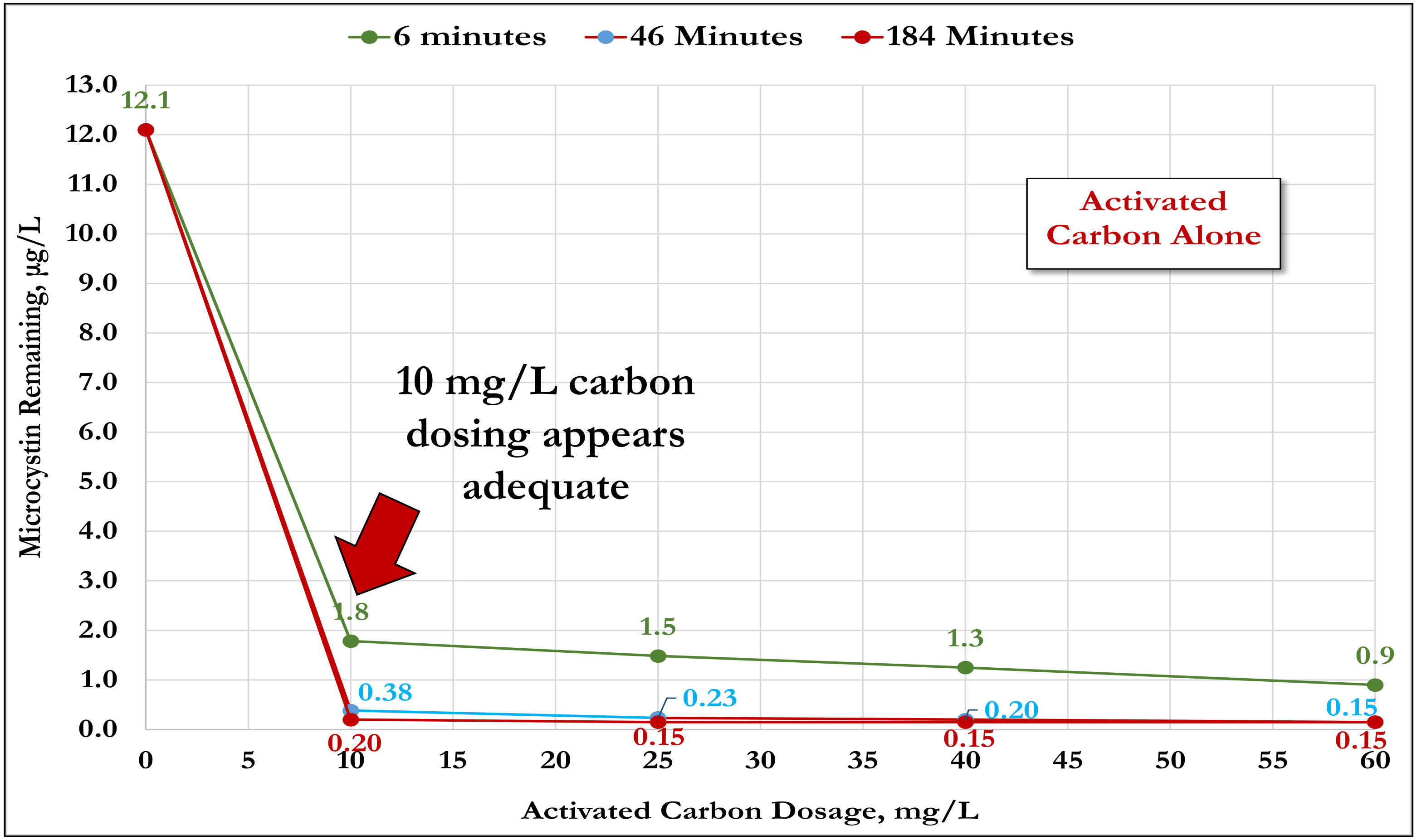
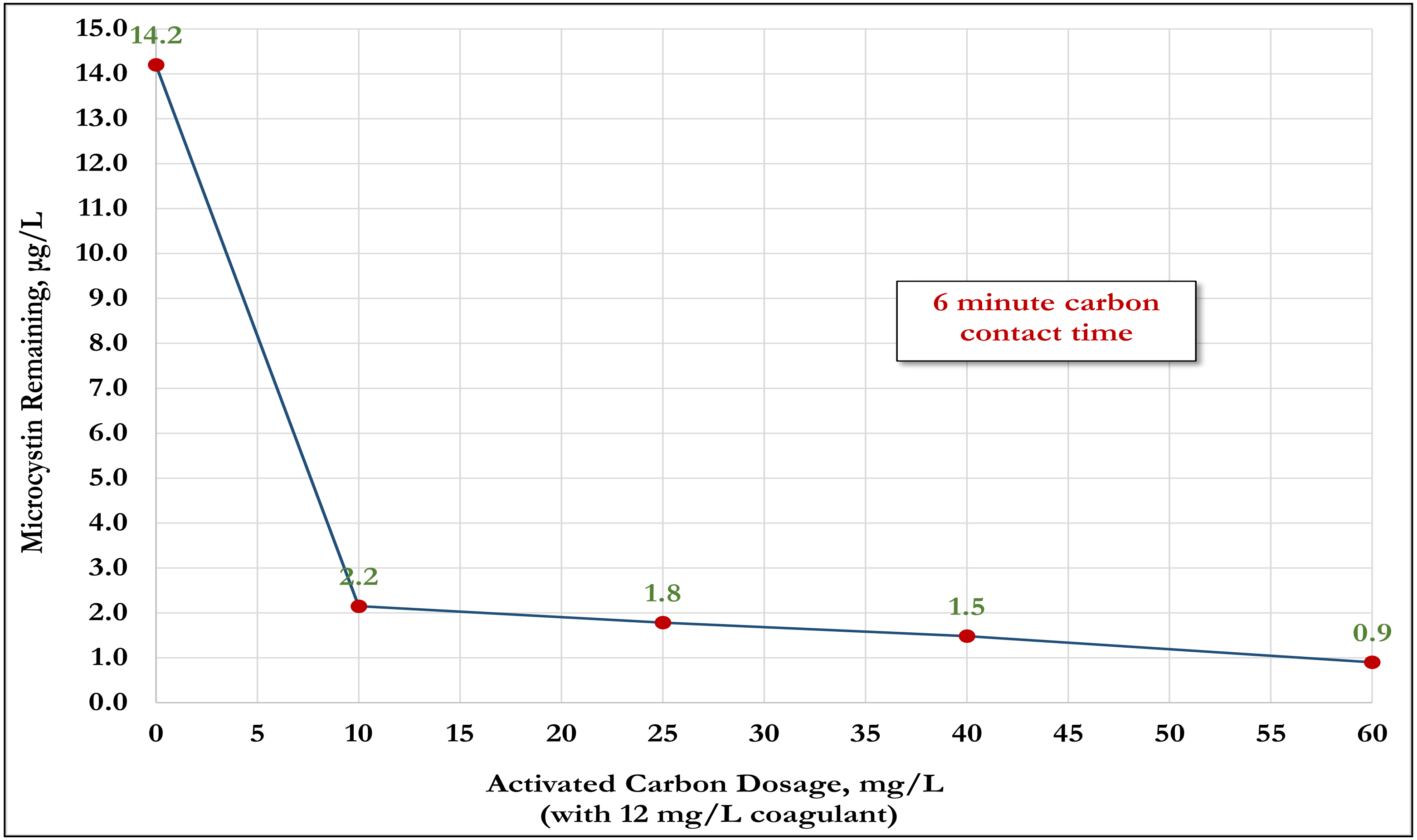


# Challenge Study Results

- Carbon /coagulant (round 2)
  - Permanganate and carbon dosing the same
  - SternPac 50 coagulant added after 6 minutes carbon contact in raw water piping (normal rapid mix step)
  - Simulated carbon adsorption along with coagulant dosing in rapid mix and flocculation
  - Same sedimentation treatment
    - Any carbon coagulant interference
    - Actual carbon adsorption with coagulant present

# Challenge Study Results

- Carbon Adsorption – raw water piping (round 2)



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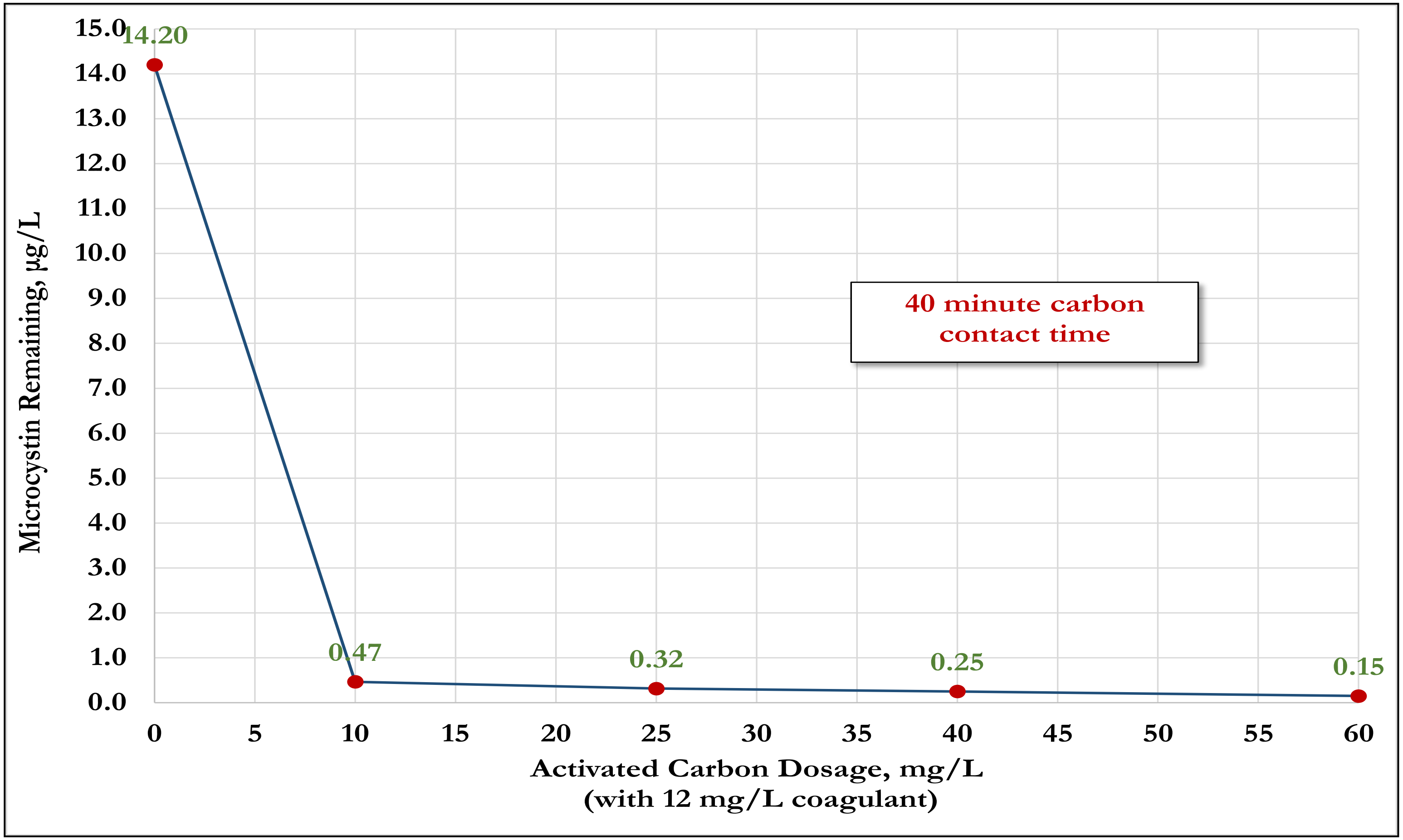
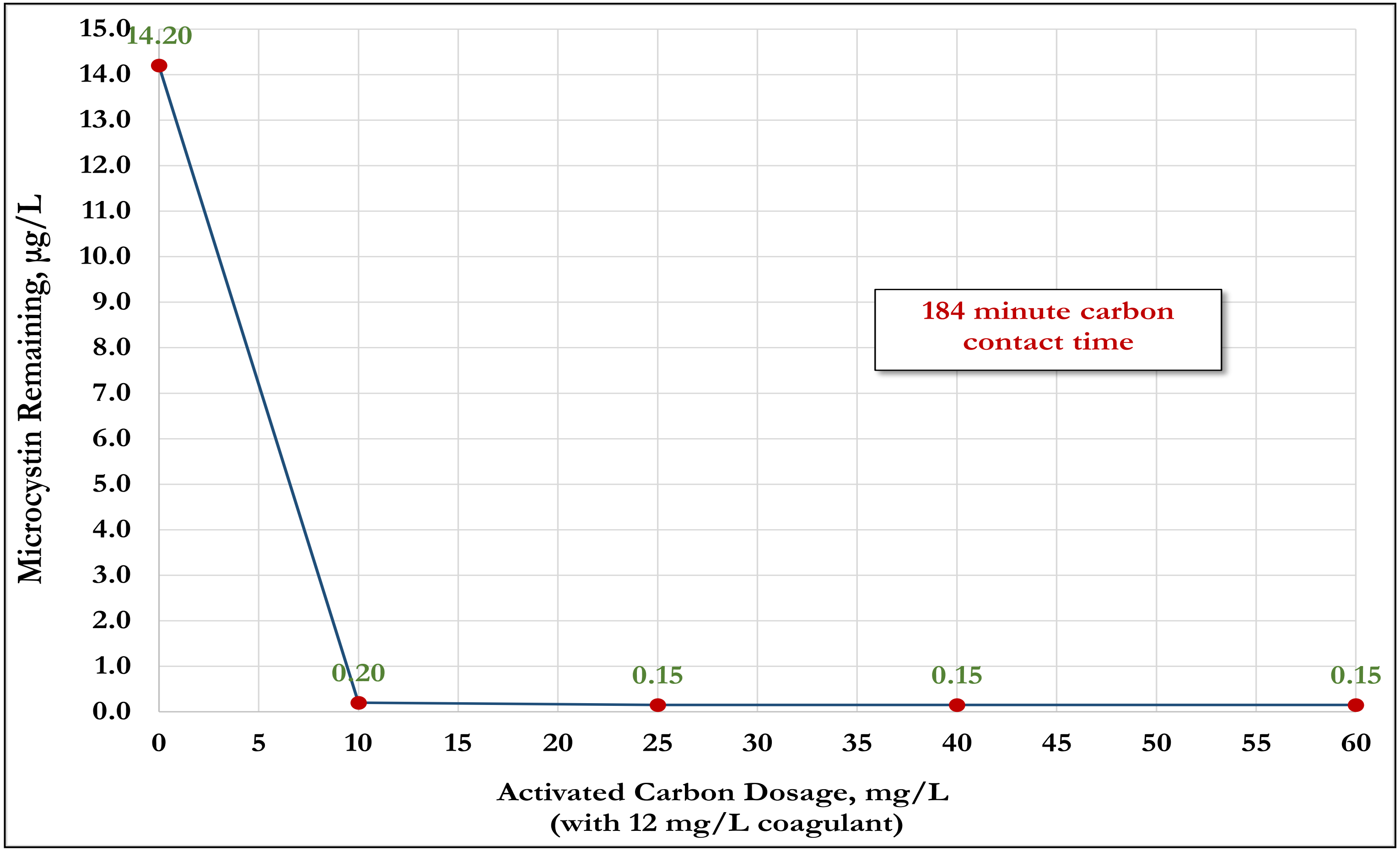
- Carbon Adsorption – rapid mix/flocculation (round 2)



# Challenge Study Results

- Carbon Adsorption – sedimentation (round 2)



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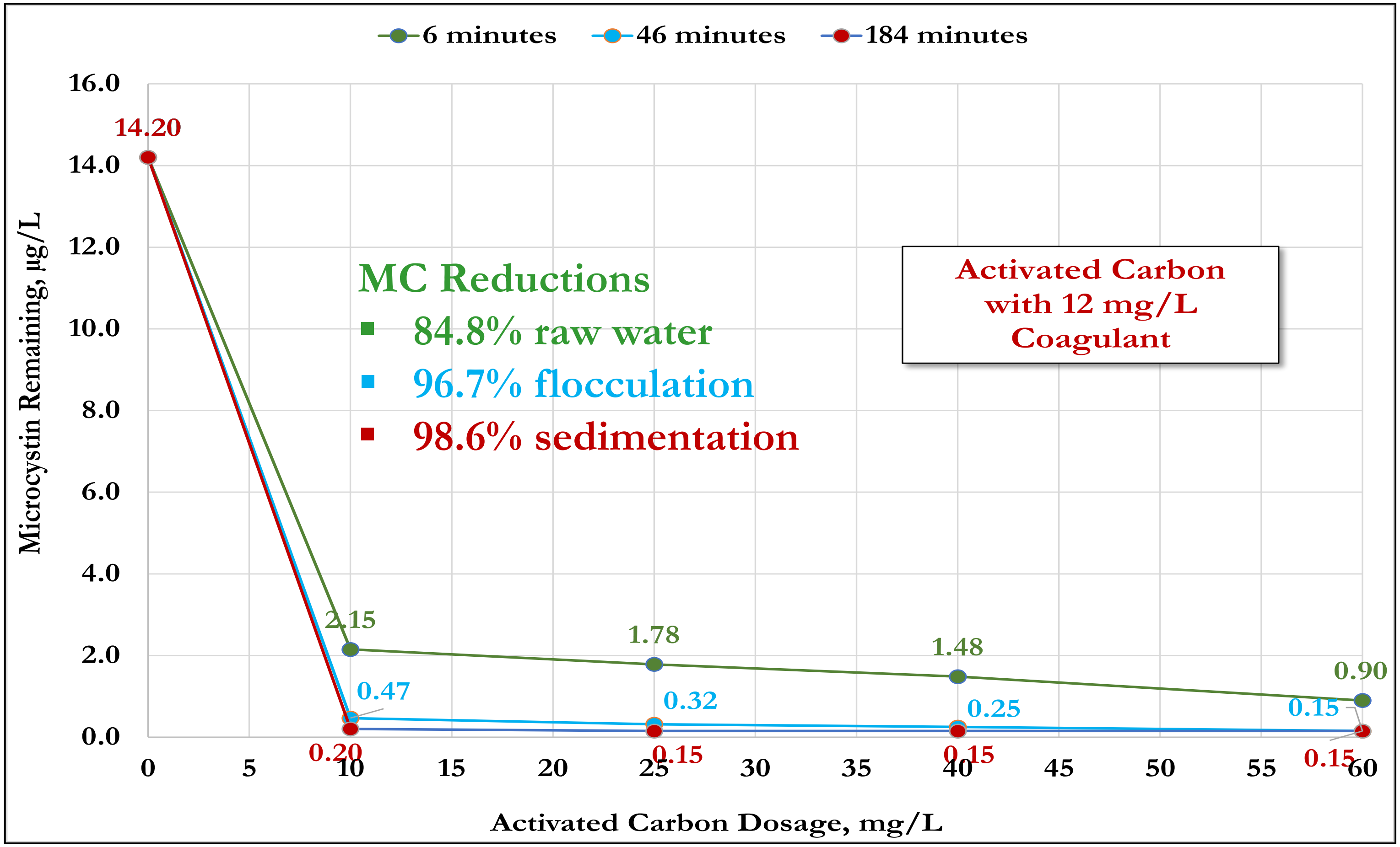

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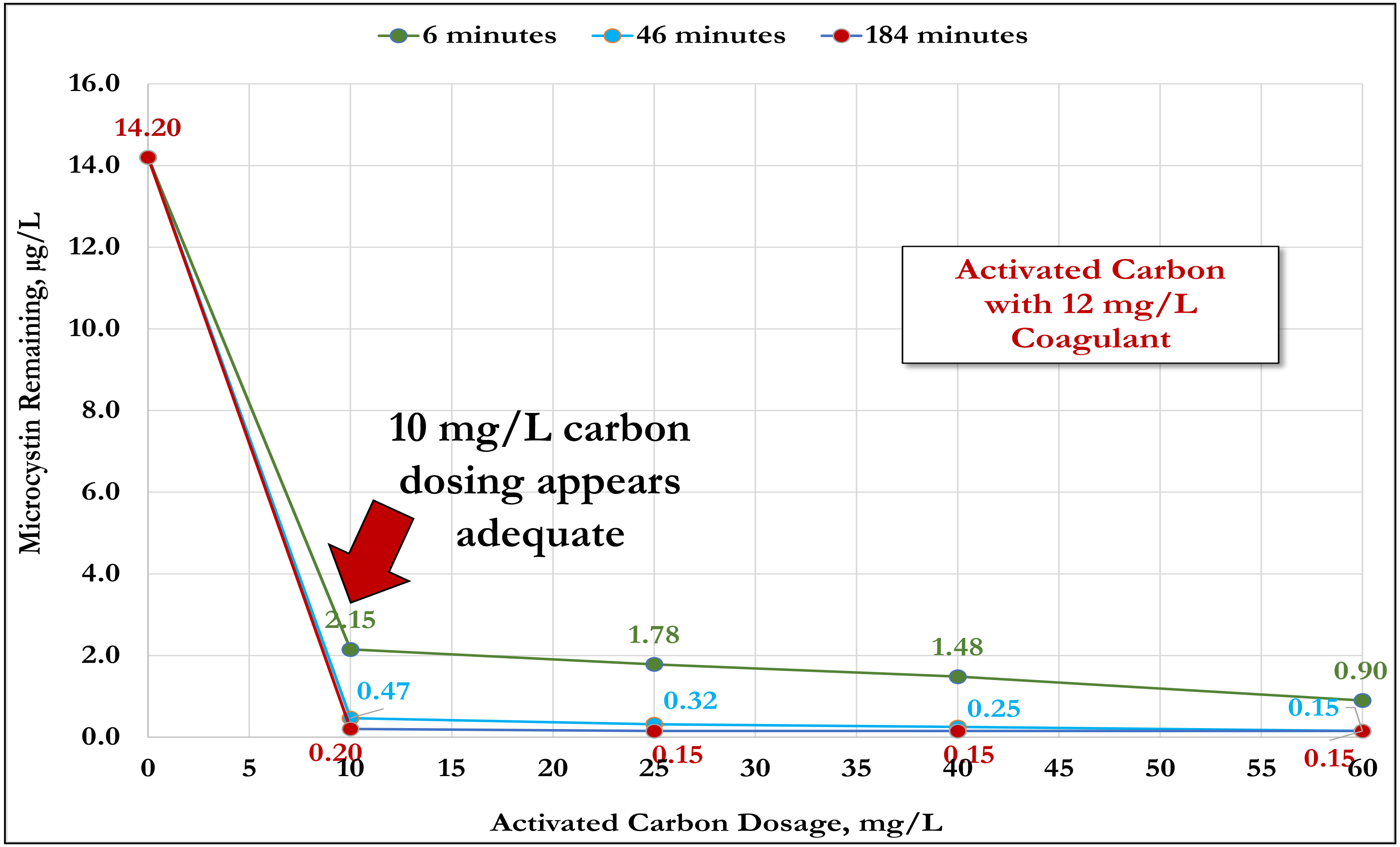
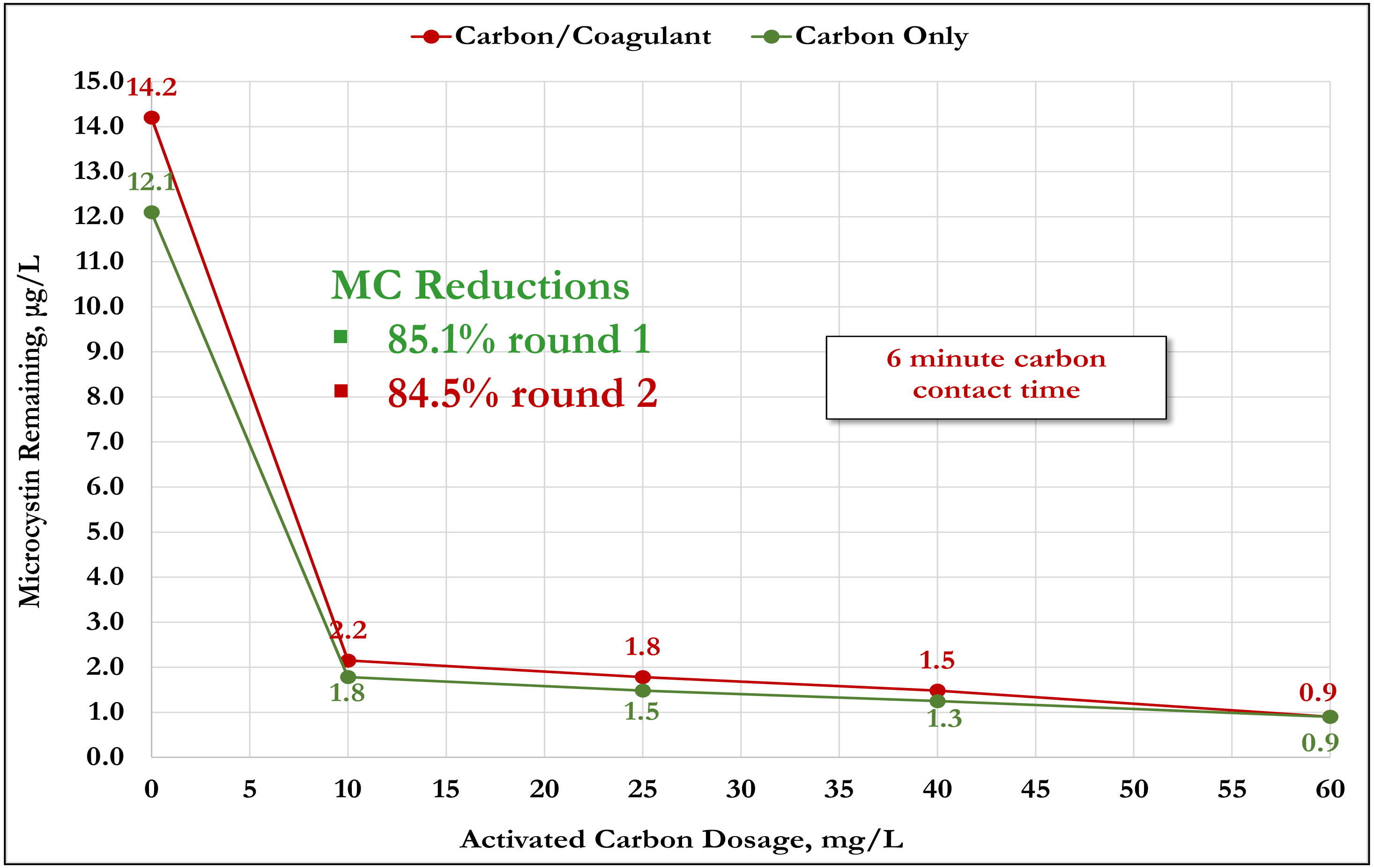


# Challenge Study Procedures

- Adsorption comparisons Rounds 1 and 2



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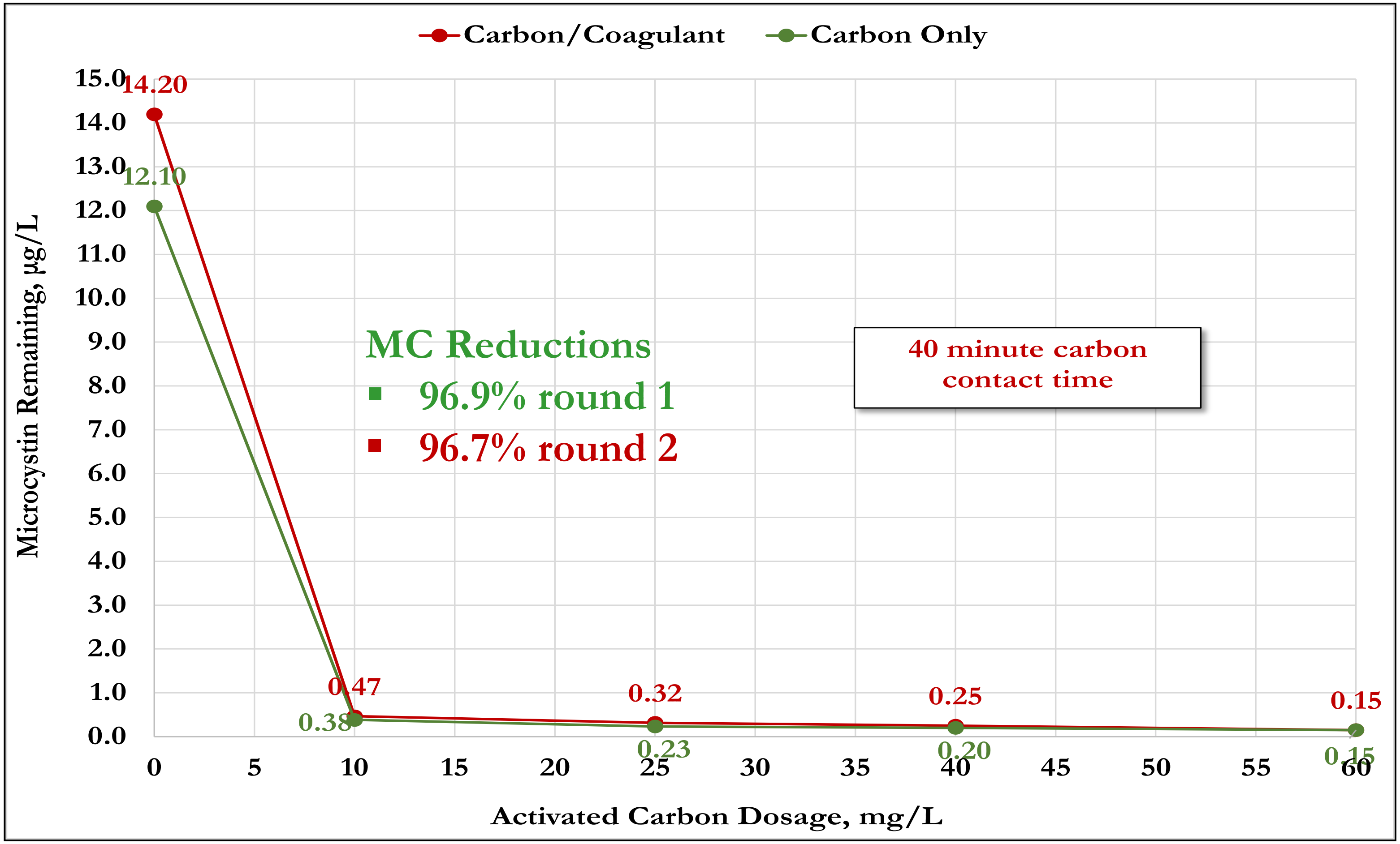

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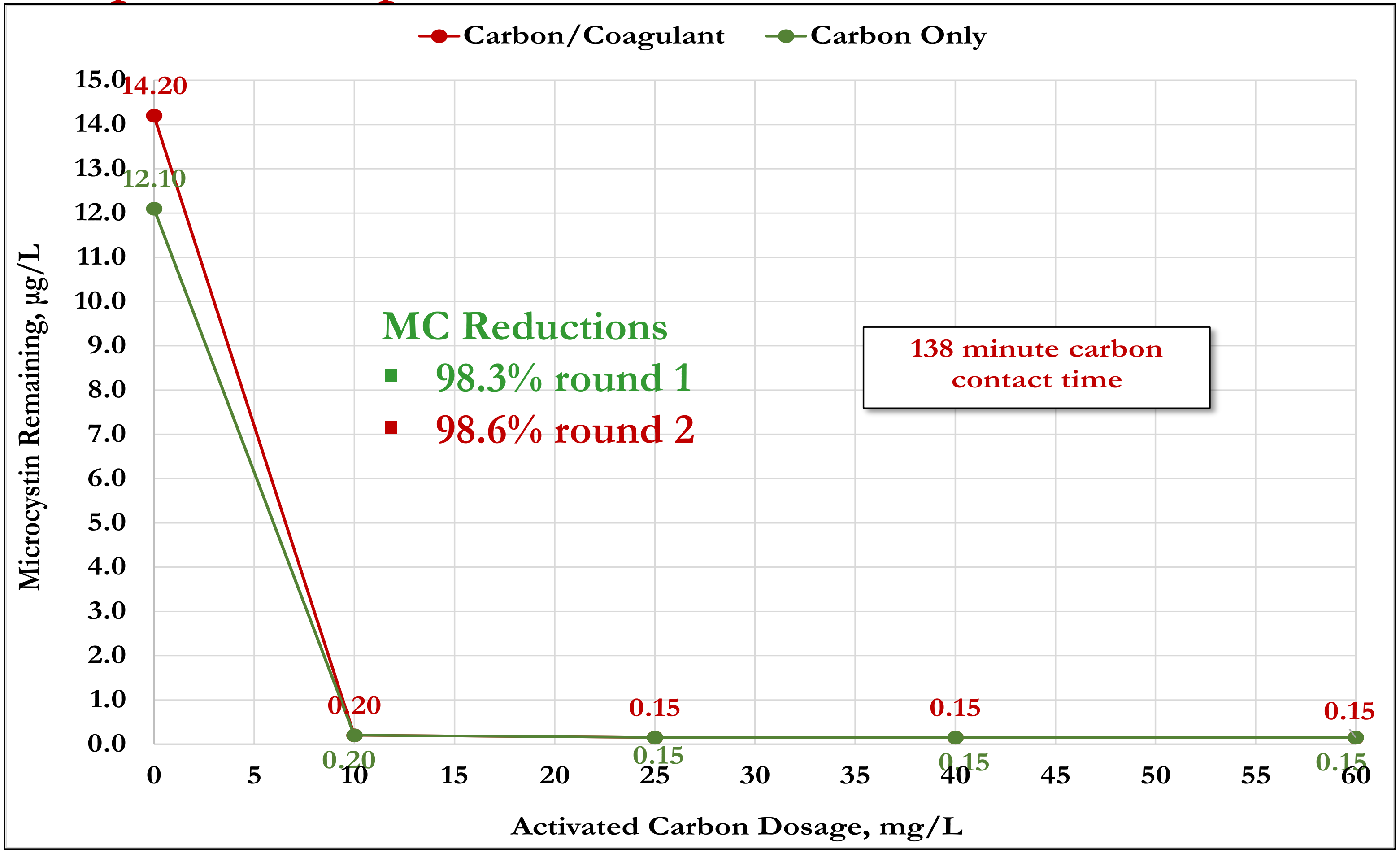
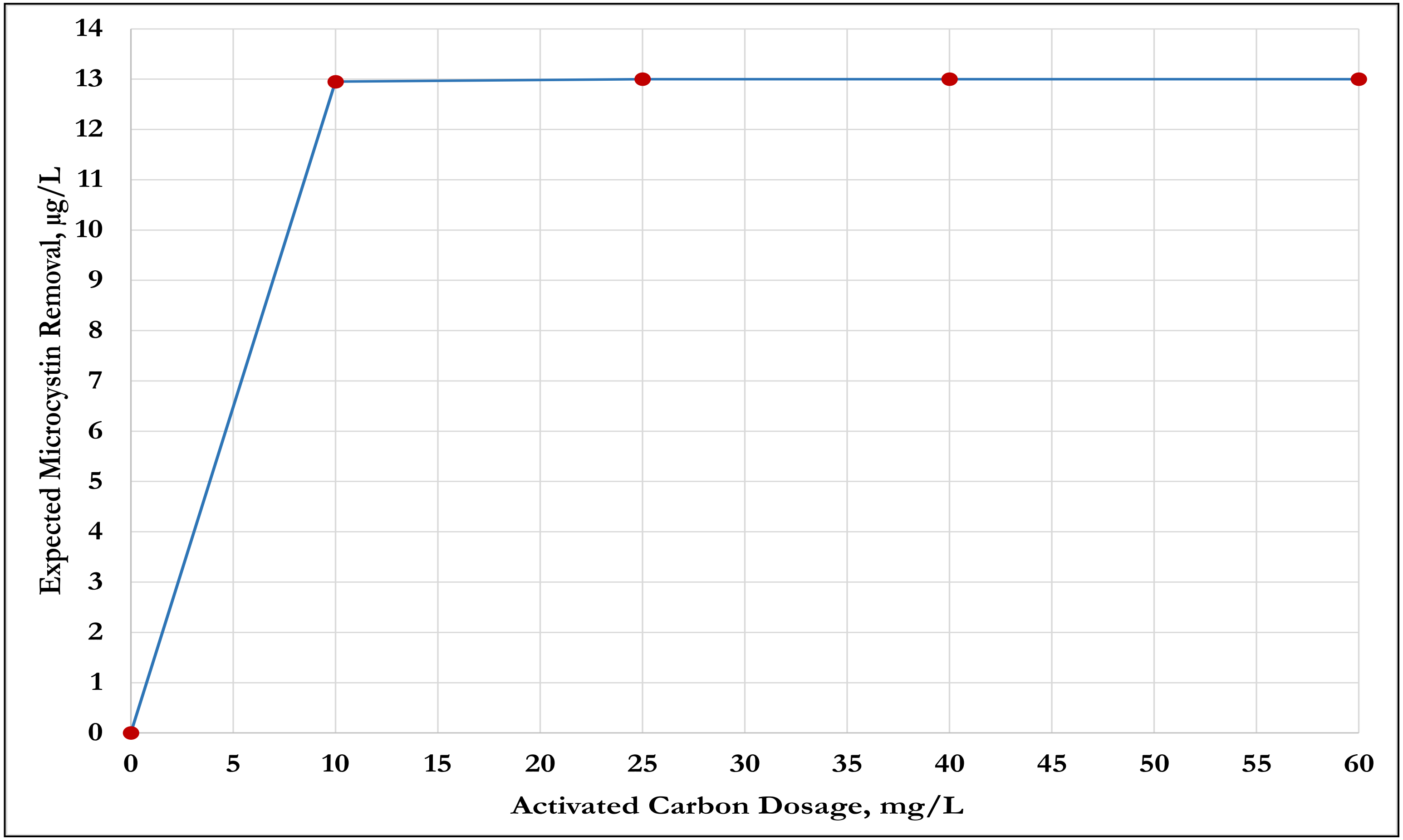


# Challenge Study Results

- Apparent carbon dosing curve



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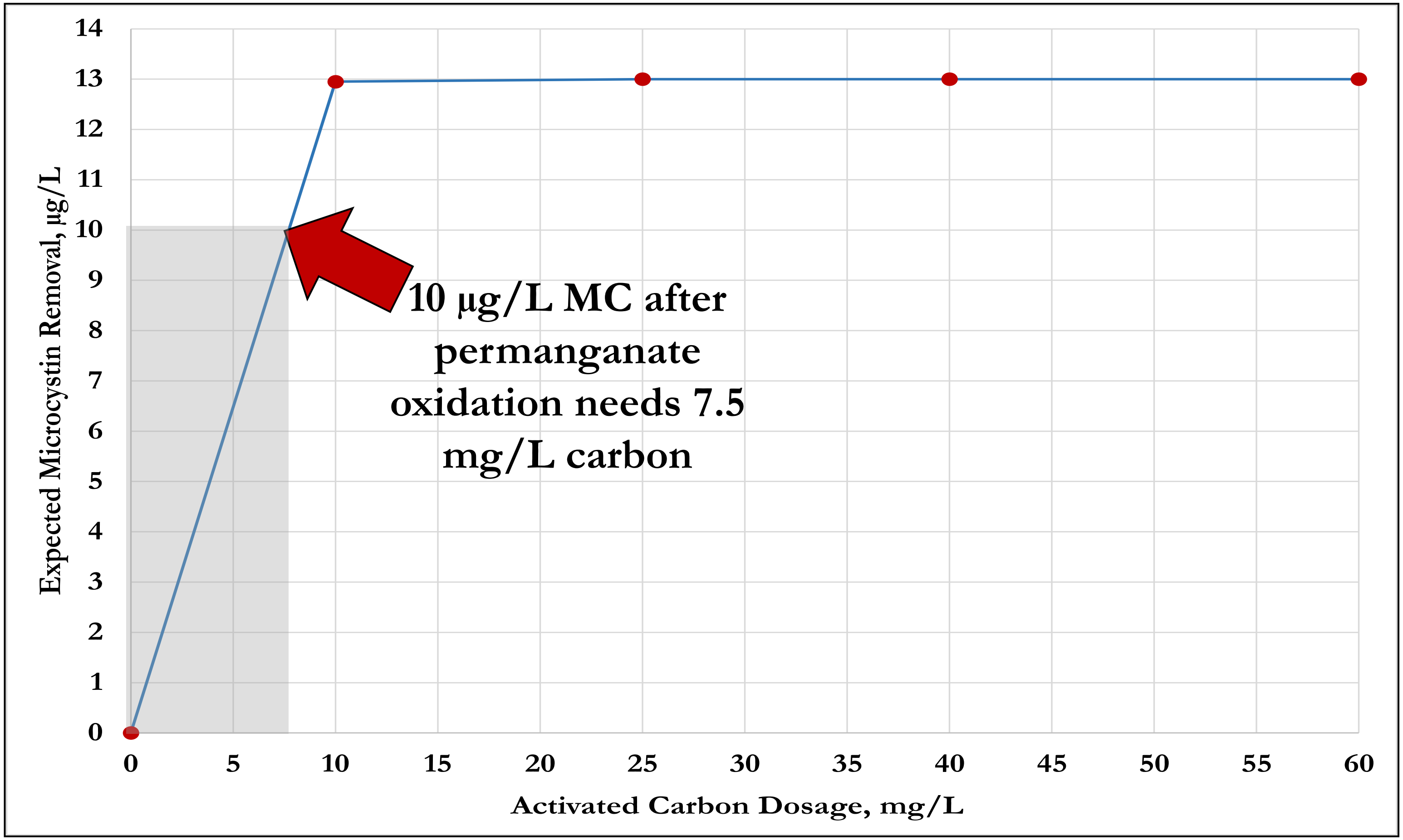
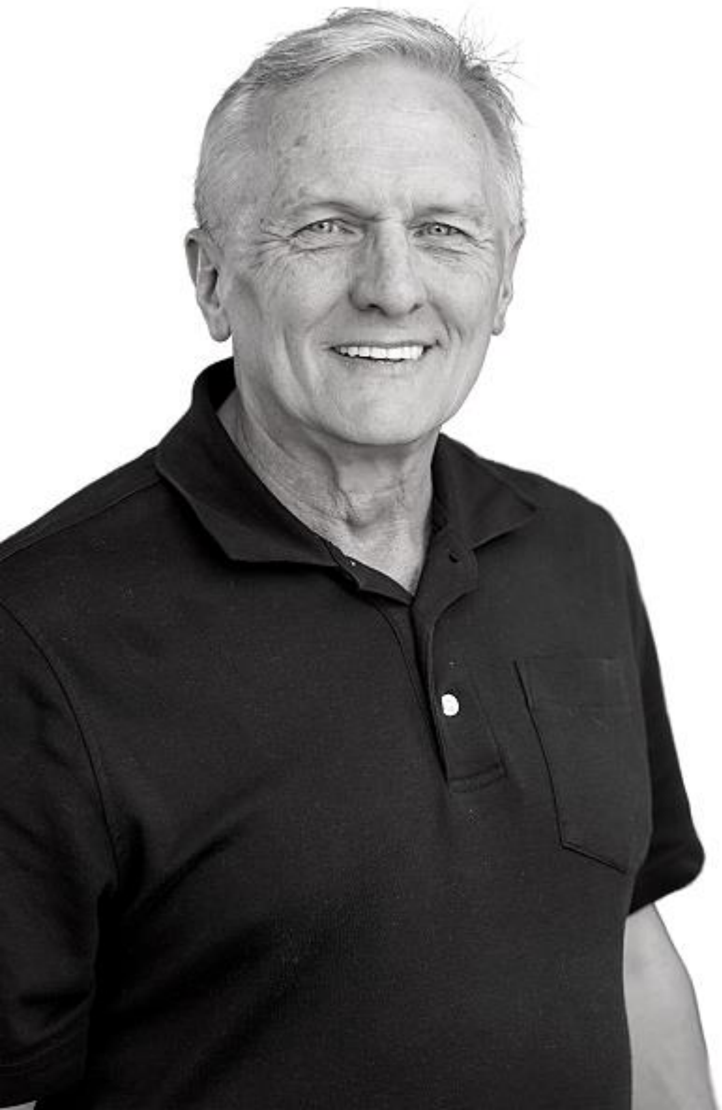


# Challenge Study Results

- Permanganate oxidation very effective even at low dosages
  - MC reduction could be more than 70%
- AquaSorb CB-1-MW activated carbon very effective at dosages up to about 10 mg/L (9.8 mg/L from study)
  - More than 84% removal in 6-minute raw water piping contact time
  - More than 96% removal through flocculation treatment
  - More than 98% removal through sedimentation treatment
  - Carbon adsorption nearly identical when normal coagulant dosages applied in treatment
    - No negative impacts from coagulant feed
  - Dosages greater than 10 mg/L had little impact on reductions

# Challenge Study Results

- Separate contact tank **not needed** for carbon adsorption
- Carbon dosing curve can be used in process decisions
  - Depending on MC remaining after permanganate oxidation
- Future assessments
  - Develop permanganate oxidation curve at various dosages to optimize oxidation and residual maintenance
  - Develop chlorine pre-oxidation curve (seasonally fed for algae control)
  - Evaluate different carbon products (up to four types)
  - Develop chlorine oxidation curve for clearwell and CT (resiliency evaluation)
  - Evaluate ELISA ADDA testing in-house versus contract lab



# Questions

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