Granular Activated Carbon: A Proven Solution for PFC Removal

January 30, 2017
Introduction

• Calgon Carbon Corporation is the world’s largest producer of Granular Activated Carbon (GAC)
• Our mission: pure water, clean air, better living
• We solve purification and separation problems with an array of technologies (Activated Carbon, IX, UV, AOP, Perlites, D.E.)
• Water treatment is core competency with a diverse product portfolio

$535 million
2015 net sales

70+ years
experience

1,400+ employees

23 offices
sales and service

21 facilities
manufacturing, reactivation, equipment

240 patents
Protecting Communities from Perfluorinated Compounds
PFC Overview

Man made fully fluorinated organic compounds

Health Advisory:
70 ppt
Combined PFOA / PFOS

Why PFCs Are a Problem
- Contaminates drinking water and food
- Highly persistent / resistant to degradation
- Accumulate in the body

Where they come from....
Where are PFCs?

U.S. Drinking Water Contaminated by PFCs*

According to the U.S. EPA:
- 94 Public drinking water systems with PFC’s
- Across 28 States (Red Highlight)
- 6.5 Million Americans affected
- Not including private wells

Contaminated non-drinking water sources are not included

....THE PROBLEM IS ONLY GROWING!

Where are PFCs?

Potentially PFC Contaminated DoD Sites *

Based on the use of fire fighting foams….
  • DoD identified over 200 bases potentially contaminated
  • Across 49 States (Red Highlight)
  • Testing currently underway
  • May impact adjacent municipal water utilities

How GAC Can Help
Economic Benefits of GAC

- The average family of 4 consumes 65,700 gallons of water annually.
- Tap water filtered by GAC costs a family of 4 roughly $2.00/Month (per AWWA).
- The average 2015 price for bottled water is $1.22/gallon.
GAC is a Proven Technology

- Leading technology for removal of PFCs from drinking water and groundwater
- >15 years and >20 large installations in municipal/industrial segments & > 1000 POET GAC systems treating residential well sites
- GAC is safe & environmentally responsible - safest way to treat is to remove contaminants
- Cost effective & simultaneously removes other emerging contaminants which addresses future compliance requirements
- Reactivation of spent GAC thermally destroys adsorbed contaminants including PFC’s
Why FILTRASORB® GAC is superior
FILTRASORB® GAC

Domestically mined, domestically manufactured GAC

Bituminous coal-based re-agglomerated GAC has shown to have better performance in water applications than direct activated coal and coconut based carbons.
Granular Activated Carbon

Product differences: Re-agglomeration versus Direct Activation

Even Activation

Low Activation

Re-agglomeration

Direct Activated

Over activation in the outer Part of the granule
Activated Carbon Starting Materials

- Coconut
- Lignite
- Bituminous Coal
- Wood
The Importance Of Testing
Importance Of Testing

- PFCs/PFASs are found in trace amounts in water
- Testing is recommended – customer raw water sample
  - Isotherm
    - Quick test method for feasibility
  - Accelerated Column Tests (ACT)
    - Simulates full scale performance
    - Provides important information: carbon type, breakthrough data, usage rates
    - System design is critical

- Drinking water applications
  - Typically low concentrations (ppb, ppt)
  - Background TOC can be 10-100X the PFC/PFAS concentration
  - Modeling such scenarios is difficult (even with other, non-PFC compounds)
  - ACT or RSSCT is beneficial

- If client timing does not permit testing, CCC recommends as a start: 10 minutes EBCT (Empty Bed Contact Time) per adsorber, with 2 adsorbers in series
Isotherms

100 ML OF SOLUTION TO BE TREATED
SOLUTION IN CONTACT WITH INCREASING AMOUNT OF CARBON
EQUILIBRIUM REACHED

FILTRATION

ANALYSIS OF RESIDUAL CONCENTRATION
Isotherm

GAC Loading

Inlet concentration

Concentration [mg/l]

Loading [mg/g]
RSSCTs / ACTs Test Methods

- **HIGH PRESSURE MINI-PUMP**
- **FEED SOLUTION FROM CARBOYS OR COLLAPSIBLE TEFON BAGS**
- **SS TUBING**
- **1/4" O.D. COLUMN (316 SS)**
- **SAMPLE COLLECTION**
FILTRASORB® Comparative Performance Data

RSSCT PFOA Breakthrough Comparison

- Virgin Filtrasorb
- Coconut 8x30
- Coconut 12x40
- Feed PFOA
- 50% Feed PFOA

BedVolumes Treated (BV)

PFOA (ppb)

70 ppt EPA Health Advisory Exposure Limit
FILTRASORB® Comparative Performance Data

RSSCT PFOS Breakthrough Comparison

Bed Volumes Treated (BV)

PFOS (ppb)

Virgin Filtrasorb
Coconut 8x30
Coconut 12x40
Feed PFOS
50% Feed PFOS

70 ppt EPA Health Advisory Exposure Limit
Conclusions from Analysis

- Bituminous coal-based re-agglomerated GAC significantly outperforms coconut based GAC

- Lab analysis supports bituminous coal-based re-agglomerated GAC is the best product for PFC removal
Case Study
PFC Isotherm - NY Water Source

PFC Removal
FILTRASORB® Isotherm Plot

Theoretical Max. Loading in Column System = 117 ug/g GAC
Theoretical Carbon Use Rate = 0.04 Lbs. GAC/1000 Gal. Treated

Contaminant Loading (ug/g GAC)

Total PFOA Concentration (ng/L)
TOC Isotherm - Same NY Water Source

TOC Removal
FILTRASORB® Isotherm Plot

Theoretical Max. Loading in Column System = 4.2 g/100g GAC
Carbon Use Rate = 0.20 Lbs. GAC/1000 Gal. Treated

TOC at 1.38 ppm
PFC/TOC Customer ACT Data

Simulated Days of Operation for PFCs and TOC

Non detect after 620 simulated days of operation
Conclusions from Case Study

• FILTRASORB® can remove PFCs to non-detectable levels

• TOC does not appear to compete strongly with PFC

• FILTRASORB® is effective for > 620 simulated days of operation

• Temporary System: 2 x 10’ diameter vessels, 20,000 lbs GAC each

• Permanent System: 2 x 12’ diameter vessels, 40,000 lbs GAC each
Equipment and Reactivation
Carbon Adsorption Equipment

Numerous “base” options - customized for customer’s requirements...

Model 8
Model 12
Model 14
Model 10
Model 12-40
Reactivation of GAC

- Carbon reactivation is a thermal treatment process in which adsorbed chemical constituents are removed from spent activated carbon.
- The desorbed chemical constituents are thermally destroyed in the reactivation process.
- Carbon is then reusable.
- Frequency of reactivation is dependent on application.

CCC has over 10 years of experience reactivating carbons with PFCs.
## PFC Removal: GAC vs. RO vs. IX

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<tr>
<th>Treatment Option</th>
<th>Pros</th>
<th>Cons</th>
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| **GAC** | • Significantly lower capital costs  
• Significantly lower O&M costs  
• Reactivation saves cost, destroys PFCs, & removes liability  
• Established BAT for a long list of organic contaminants | • High NOM can increase use rates |
| **RO** | • Removes salts / inorganics that GAC cannot | • Concentrated waste water disposal liabilities & costs  
• More energy / CO₂ intensive  
• High maintenance cleaning and replacement of fouled membranes  
• Removes healthy minerals |
| **Ion Exchange** | • Resin can be regenerated  
• May be more economical for certain source waters (i.e. high levels of nitrate) | • High cost of reagent  
• Regeneration produces disposal liabilities & costs |
CCC Advantage

CCC has offered the preferred and total treatment solution for PFC removal for 15 years with the FILTRASORB® product line.

GAC is the leading technology for removal of PFCs.

Calgon Carbon is ready to respond immediately with technical services, equipment and carbon supply.

Spent carbon can be returned to CCC for reactivation thus thermally destroying the PFCs and eliminating future liability.
• Provide a proven and cost-effective packaged solution
• Perform laboratory and field testing
• Ensure proper equipment design
• Rapid deployment of temporary treatment systems
• Experienced sales, field service and applications engineering teams
• Carbon reactivation services
Questions
Thank you.

www.calgoncarbon.com/PFOA
Send additional questions to: pfcSolutions@calgoncarbon.com