Understanding the Carbon Footprint of Fixed Media PFAS Treatment Systems: Life Cycle Assessment and Eco-Efficiency Analysis

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Closed loop GAC leads to an 80% reduction in carbon footprint in this PFAS water treatment system.

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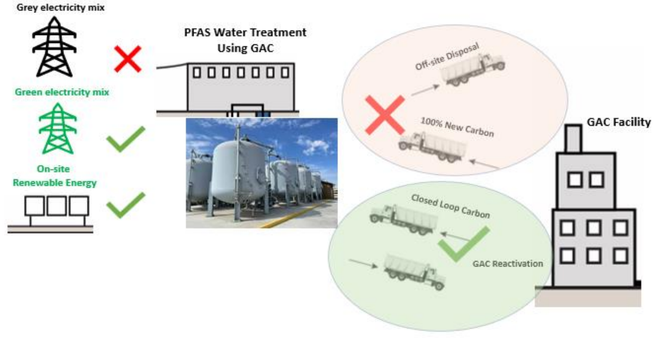
Goal

This study compared the impact of the scale in fixed media PFAS treatment systems on the carbon footprint (CF) using Life Cycle Assessment (LCA) and eco-efficiency analysis. Additional solutions were proposed to further reduce the CFs of the current systems while minimizing the associated costs – i.e., optimizing the systems' eco-efficiency: based on solutions for the treatment media (e.g., closed-loop) and renewable energy consumption.

- i) Business-as-usual scenario - only for System B (scenario iB): all new Granulated Activated Carbon (GAC), disposed after use. USA grey electricity mix for on-site system's energy consumption;
- ii) Closed Loop scenario - for System A (scenario iiA) and B (scenario iiB): 90% of GAC reused after reactivation process, ~10% losses from transport and treatment replaced by new GAC. USA grey electricity mix for on-site system's energy consumption; and
- iii) Closed Loop & Renewable Energy scenario – for System A (scenario iiiA) and B (scenario iiiB): closed loop GAC with on-site system's energy consumption modified to USA green electricity.



Conceptualization of options when designing and optimizing a PFAS Water Treatment System Using GAC.

Methodology

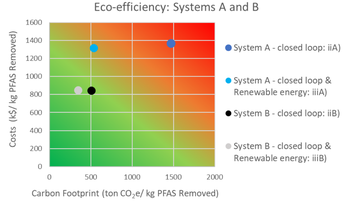
Following an Attributional LCA modeling approach, the LCA study was developed according to ISO 14040:2006 and ISO 14044:2006 standards. The CF was assessed using the SimaPro v9.3.0.3 software, the Ecoinvent database v3.8, and the Environmental Footprint 3.0 method until the characterization phase. ISO 14045:2012 was followed for the eco-efficiency analysis, which aimed to identify the solution with the best service value and the lower CF.

The approach considered raw materials extraction, processing, transportation, the system's use stage and end of life. Results were normalized to the quantity of PFAS (PFOA+PFOS) removed (1 kg). Eco-efficiency analysis was conducted based on total cost ($k).

Results of the study are based on 21 months of operational data from two systems installed for the treatment of PFAS containing water. System A had a capacity of 100 gallons per minute and System B of 700 gallons per minute.

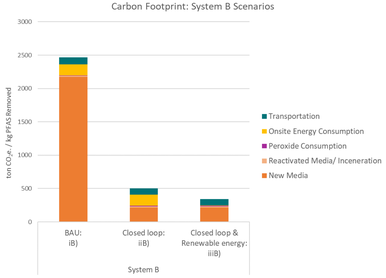
A kg of PFAS…….what does that mean?????

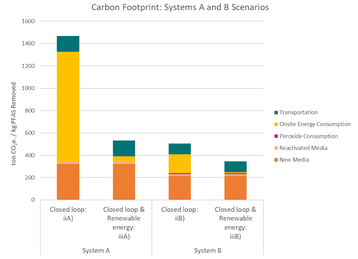
Concentration (ng/L)	Operational Flow (gpm)	Time to Reach 1 kg	Total Volume to Reach 1 kg (Million gal)
100	500	10 years	2,700
1,000	500	1 year	270
10,000	500	1 month (36 days)	27



Eco-efficiency results normalized to 1 kg of PFAS removed from water.

Findings





Carbon footprint results normalized to 1 kg of PFAS removed from water.

As observed, the total CF was dramatically reduced (80%) using closed-loop GAC. The reduced scale of the system (100 gpm) resulted in an ~200% increase in CF of iiA) compared to iiB) due to the on-site energy consumption (accounting for 67% of the total CF). Switching to green electricity resulted in CF reductions of ~30% for System B and ~60% for System A.

In conclusion, the larger System B Closed Loop offers an optimized CF promoting centralized treatment. Transition to renewable energy in any scenario is the most eco-efficient solution and should be incorporated, particularly if centralized treatment is impractical.