

Effective Removal of Contaminants of Emerging Concern by Biologically Active Filters (BAFs)

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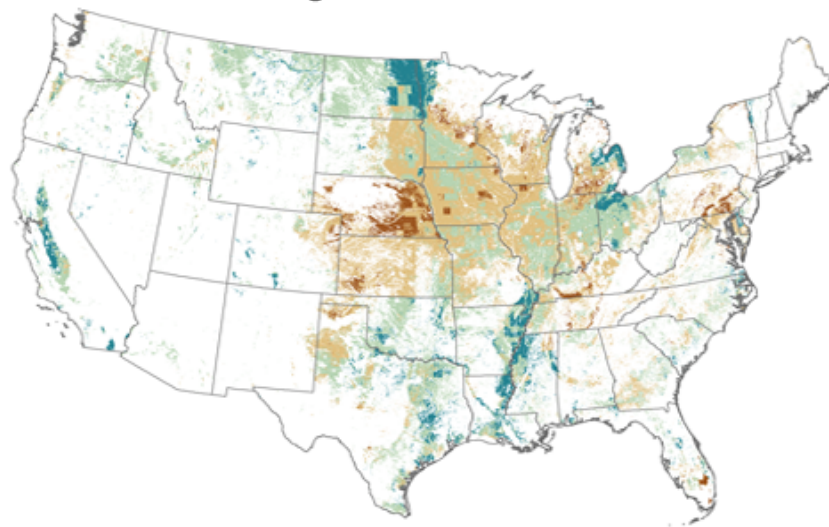
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Environmental Technologies

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CECs Have Invaded the Subsurface

Likelihood that atrazine plus deethylatrazine will exceed drinking-water standard in shallow groundwater underlying agricultural areas

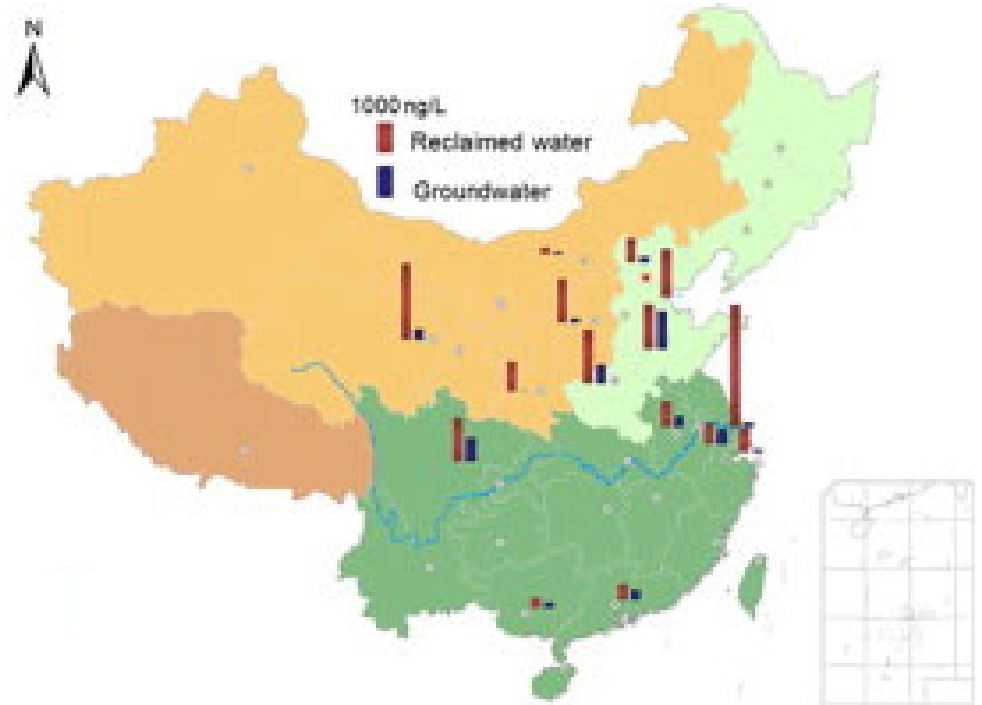


Probability of exceeding 3.0 $\mu\text{g/L}$



<https://water.usgs.gov/nawqa/pnsp/>

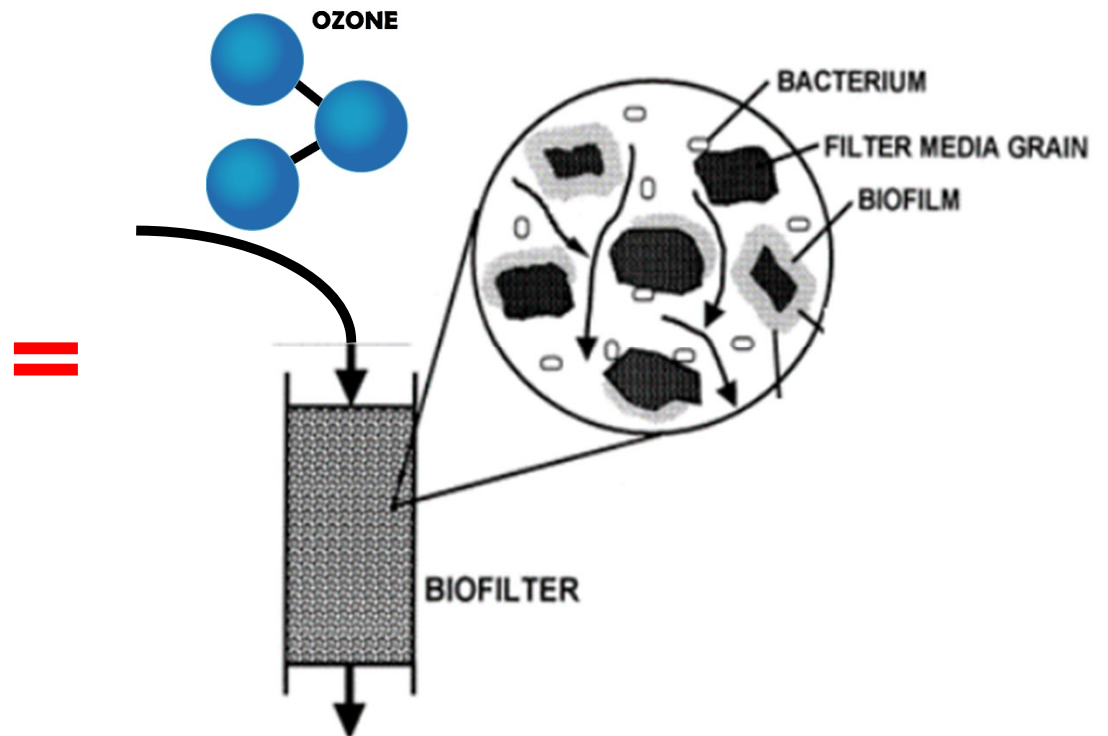
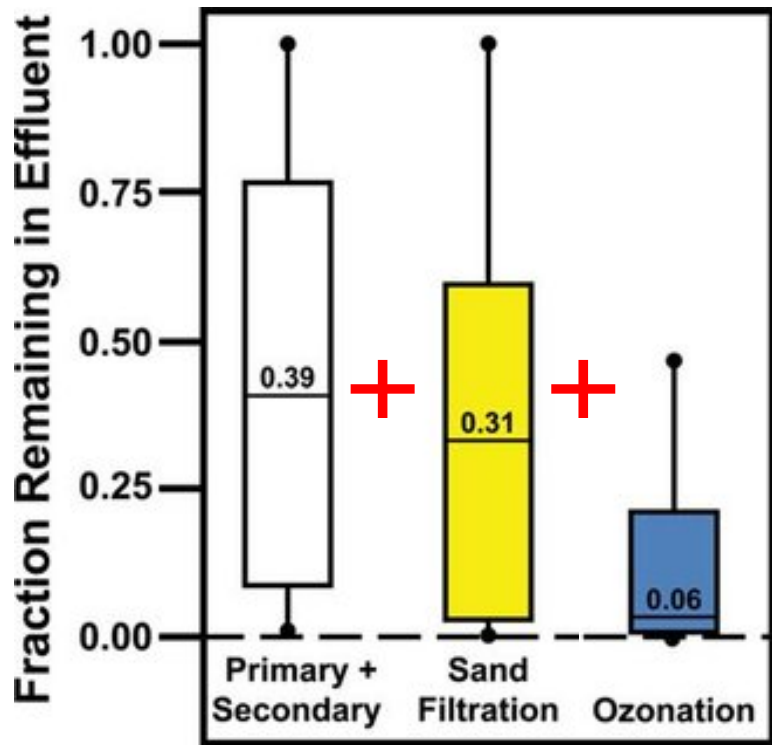
Groundwater antibiotic pollution is detected nationwide in China



Ma et al, Science of the Total Environment, 2017 3

Conventional Water Treatments Are Ineffective to Remove CECs

Biodegradation + Adsorption + Advanced Oxidation = Biologically Active Filters (BAFs)



Oulton et al.. J. Environmental Monitoring, 2010.

Objectives



Dr. Lisa Axe

- ▶ To *optimize the treatment efficiency of Biologically Active Filters (BAFs) for CEC removal.*
- ▶ To *investigate the correlation between microbial populations and operation conditions of BAFs.*



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Biologically active filters – An advanced water treatment process for contaminants of emerging concern

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Volumes 640–641, 1 November 2018, Pages 1455-1464



Microbial community analysis in biologically active filters exhibiting efficient removal of emerging contaminants and impact of operational conditions

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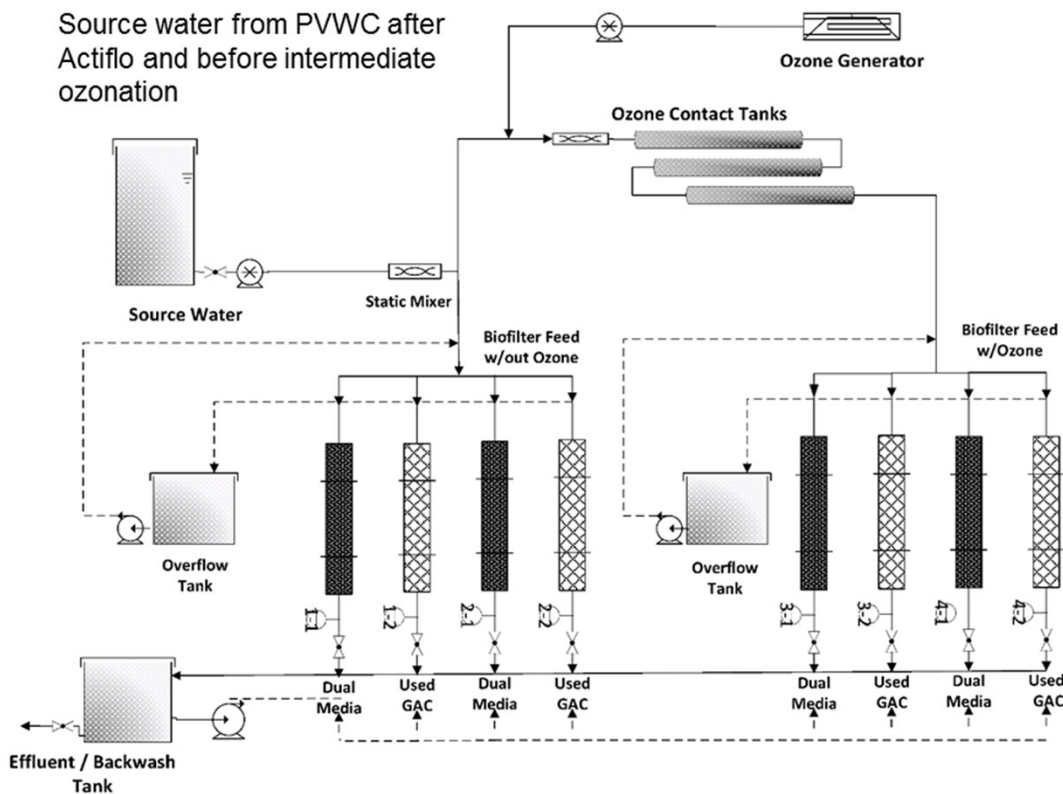
Selection of CEC Indicator Compounds

- ▶ Usage
- ▶ Occurrence in water cycle
- ▶ Persistence
- ▶ Resistance to treatment
- ▶ Physicochemical properties



Classes	Compounds
Analgesics	Acetaminophen
	Ibuprofen
Antibiotics	Erythromycin
	Sulfamethoxazole
	Trimethoprim
Antiepileptic	Carbamazepine
Beta-Blocker	Atenolol
Blood Lipid Regulator	Gemfibrozil
Fire Retardant	Tri(2-chloroethyl)phosphate
Nicotine Metabolite	Cotinine
Pesticides	Atrazine
	Aminotriazole
	DEET
Steroid	17 β -Estradiol
Psychomotor Stimulant	Caffeine
X-ray Contrast Agent	Iopromide

Bench-scale Setup of BAFs



Three key operational parameters:

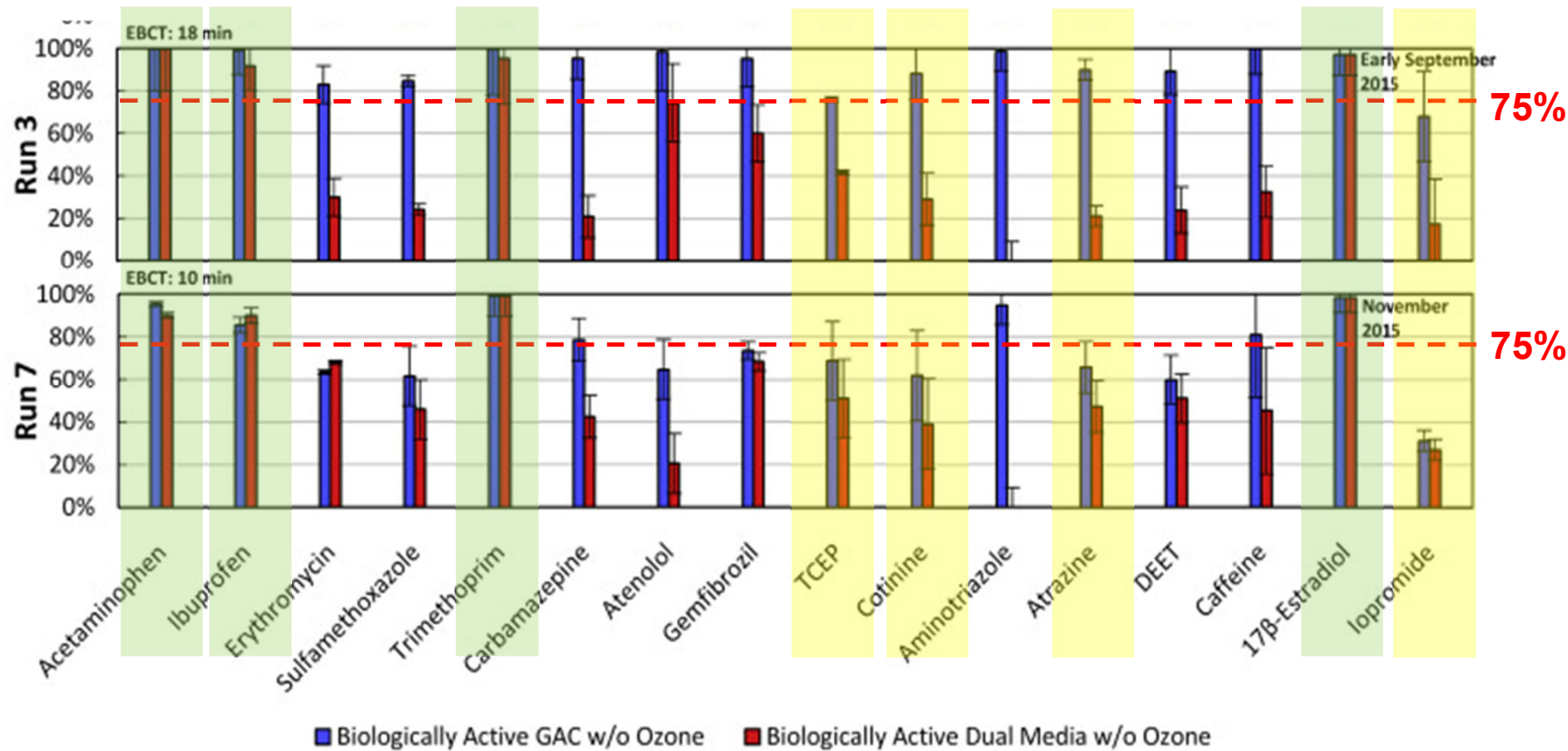
- **filter media**
(GAC vs sand/anthracite)
- **pre-ozonation**
(O_3 vs $O_3+H_2O_2$ vs no)
- **empty bed contact time (EBCT)**
(10 min vs 18 min)



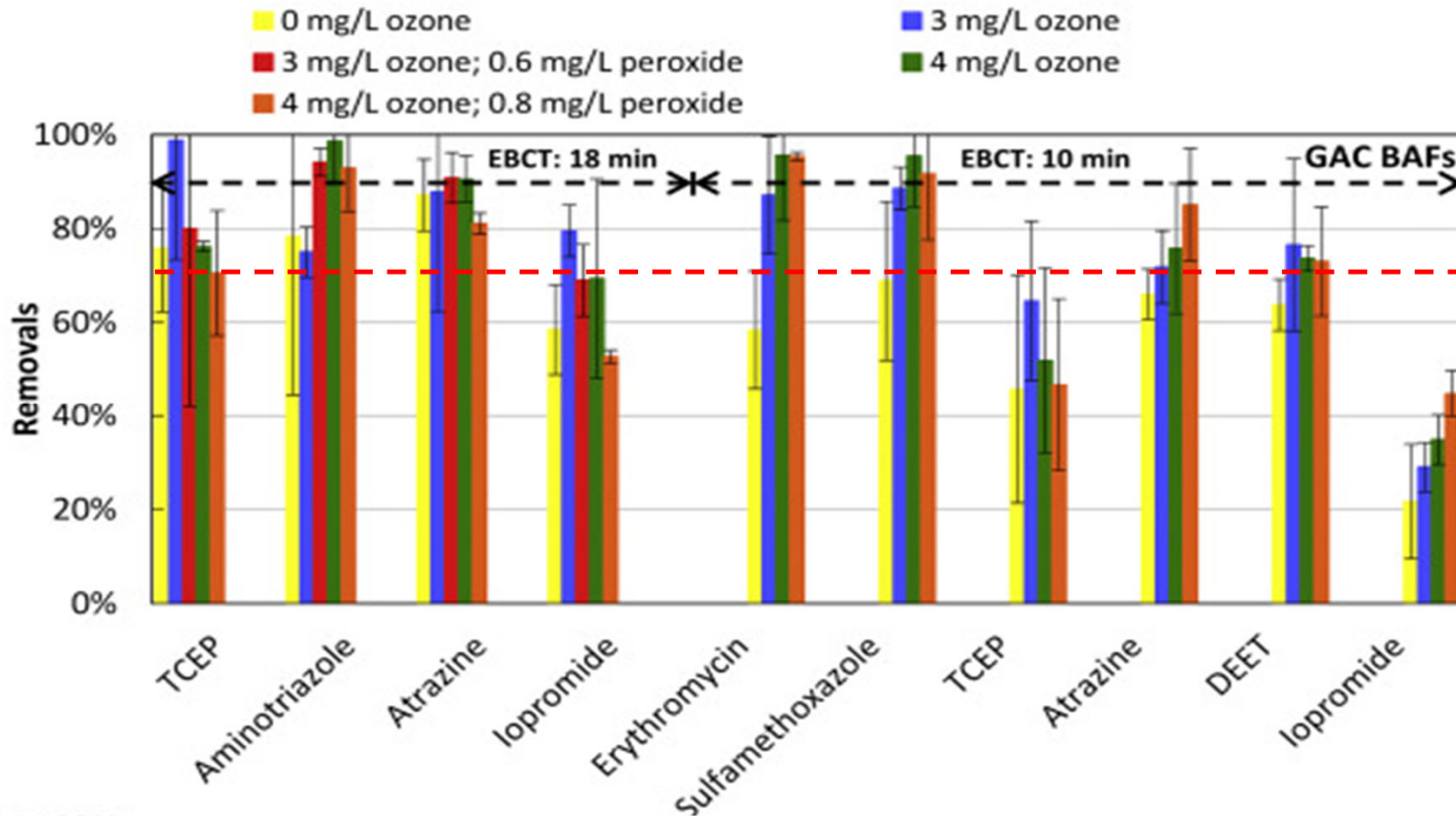
Efficient Treatment of CECs Is Achieved with GAC as the Media and Long EBCT

EBCT = 18 min

EBCT = 10 min



Pre-ozonation Enhances the Removal of the More Recalcitrant CEC Compounds

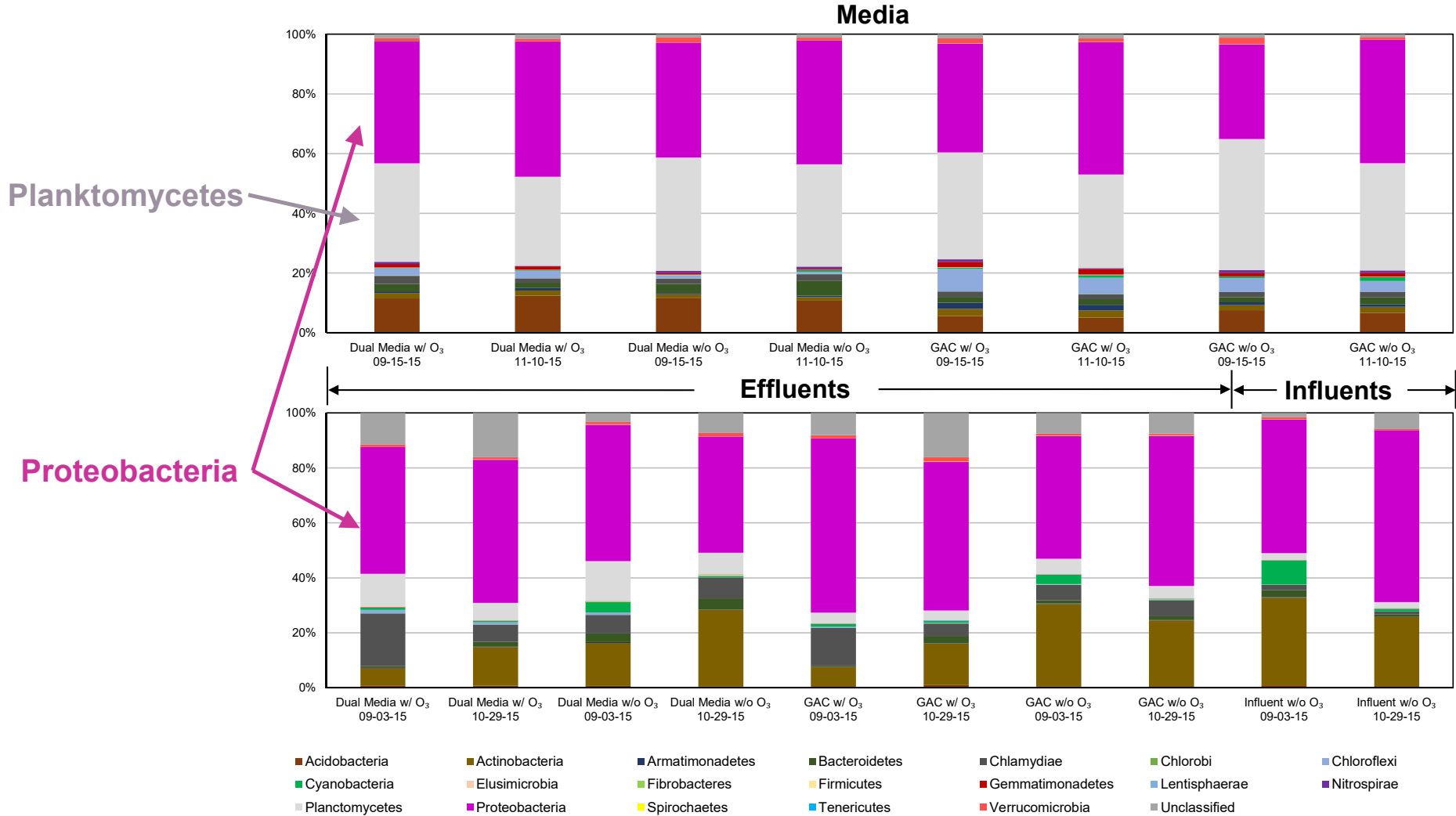


Zhang, S., Gitungo, S., Axe, L., Raczko, R. and Dyksen, J. 2017. Water research.

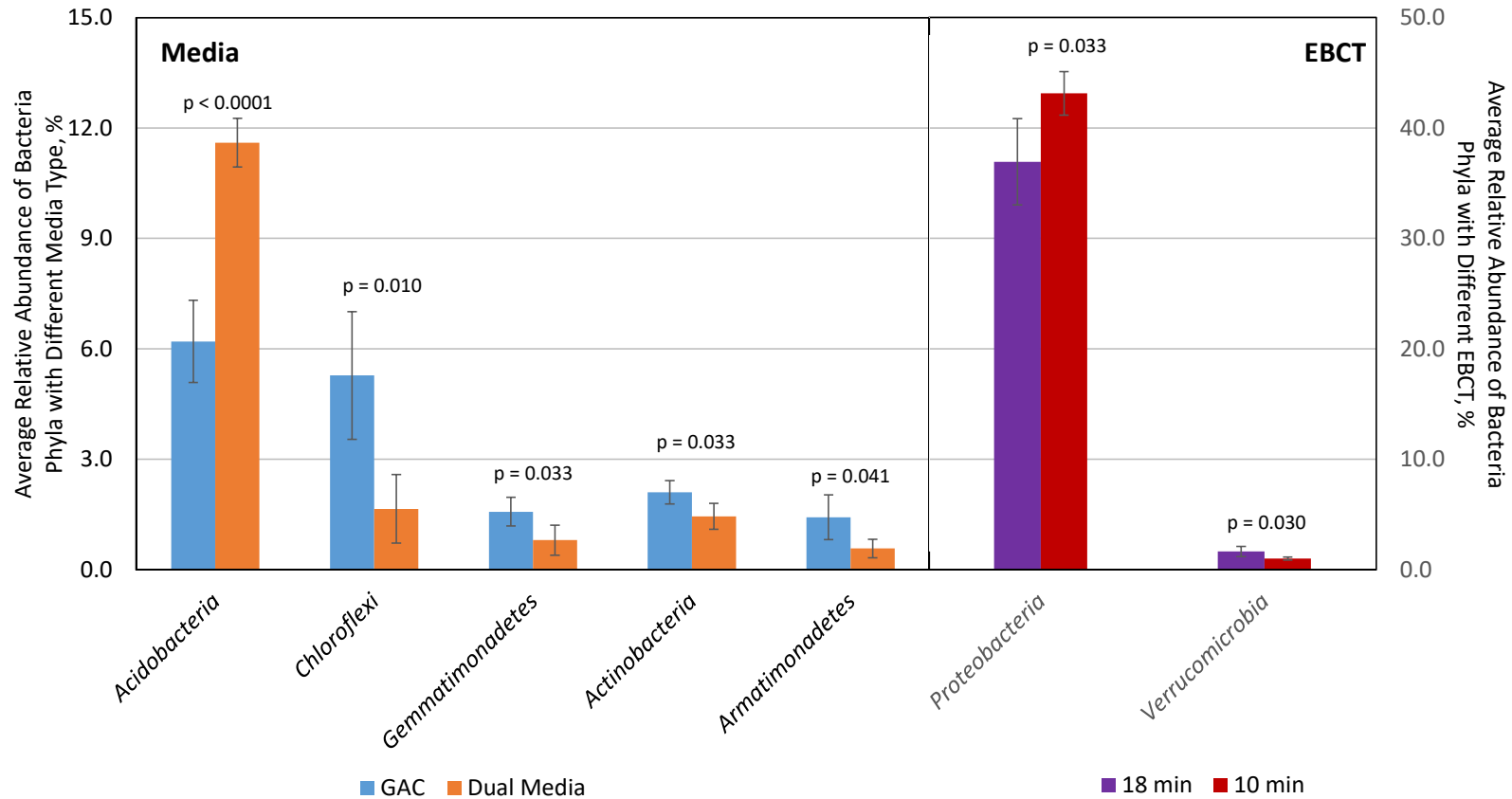
Summary I – BAF Performance

- ▶ GAC with pre-ozonation (3 mg/L) at an EBCT of 18 min resulted in CEC removals greater than 75%
- ▶ GAC BAFs showed greater removal efficiencies than dual media BAFs with or without pre-ozonation
- ▶ Applying pre-ozonation improved removals by up to 20% for GAC BAFs and up to 50% for dual media BAFs
- ▶ Increasing pre-ozonation dosage from 3 mg/L to 4 mg/L (without H₂O₂) or adding H₂O₂ (0.6 mg/L) showed (limited) improvement from 5% to 20%
- ▶ Reducing EBCT from 18 min to 10 min revealed greater impact on GAC BAFs than dual media BAFs
- ▶ Recalcitrant compounds included TCEP and iopromide for GAC BAFs and TCEP, cotinine, atrazine, and iopromide for dual media BAFs with removals less than 60%

Distinct Bacterial Phylum Compositions in BAF Media, Influent, and Effluents

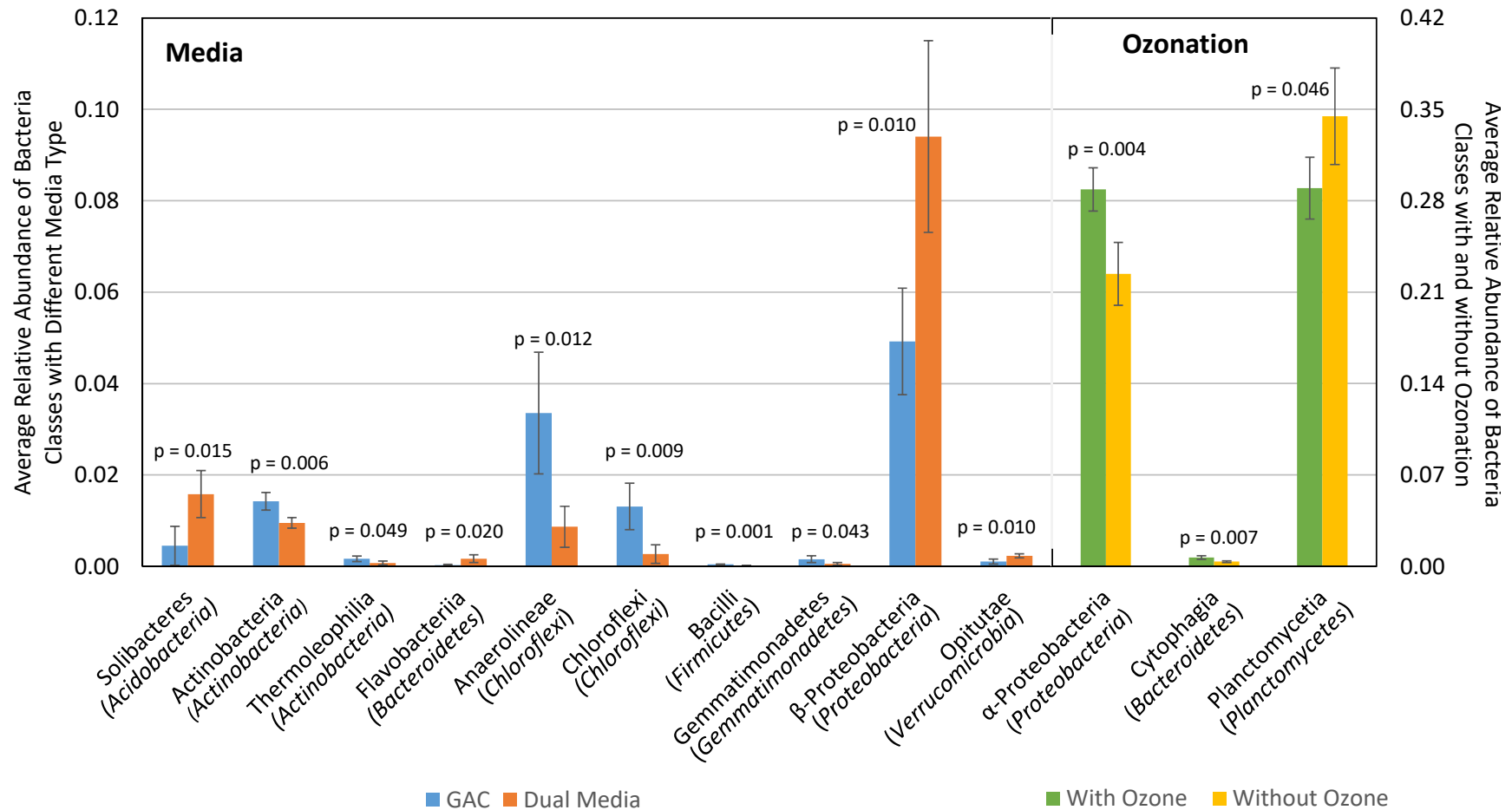


EBCT Affected the Abundance of the Dominant Bacteria Phylum – *Proteobacteria*

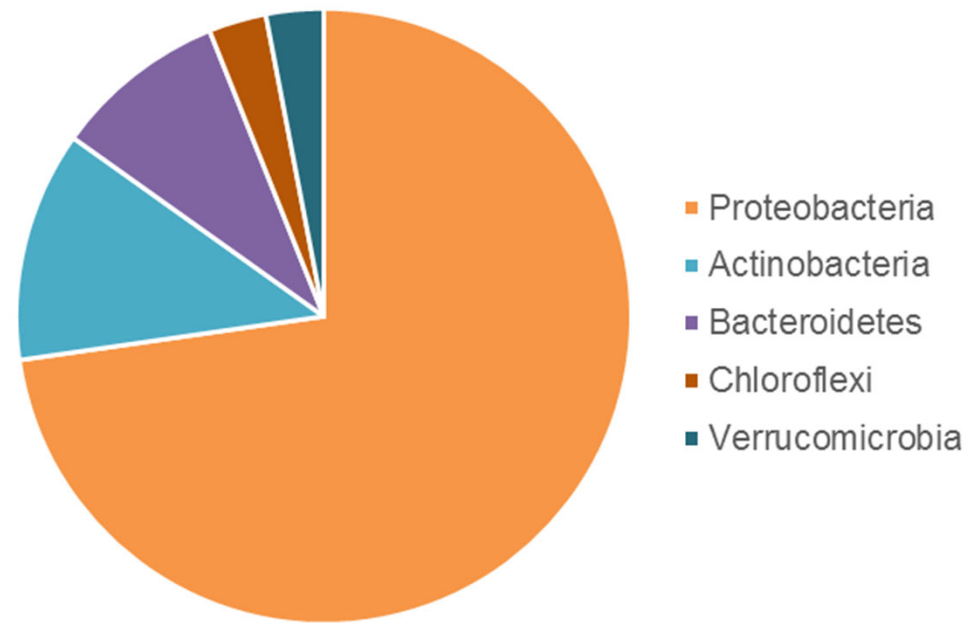
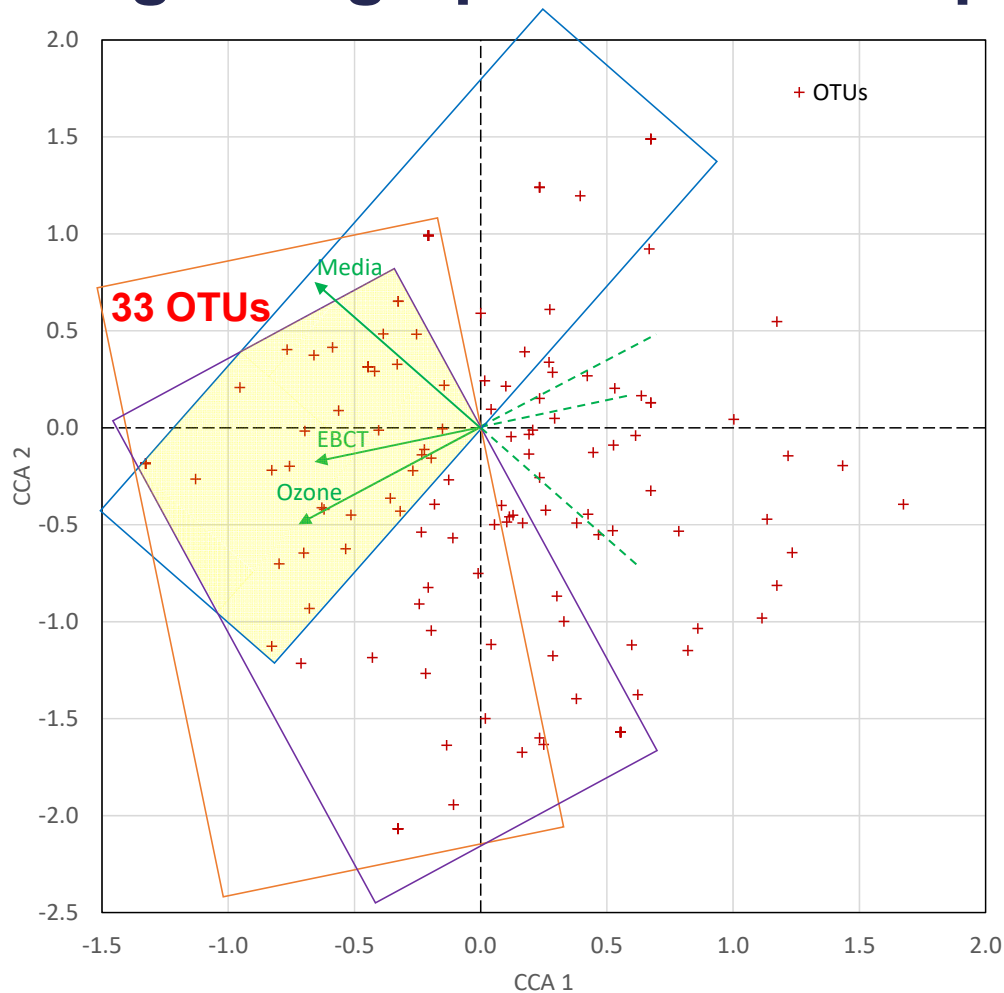


- Only bacteria with p-value less than 0.05 are shown on the figures
- p-value was calculated at a confidence interval of 95%

Ozone Statistically Affected the Abundance of Both Proteobacteria and Planctomycetes at the Class Level

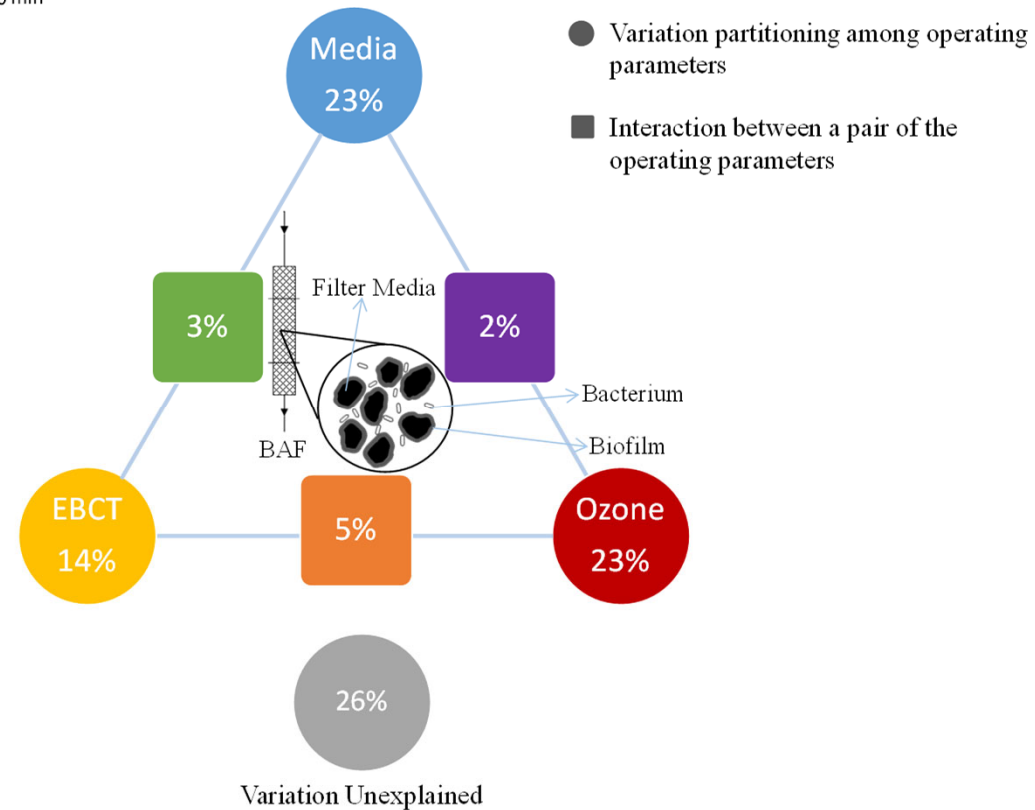
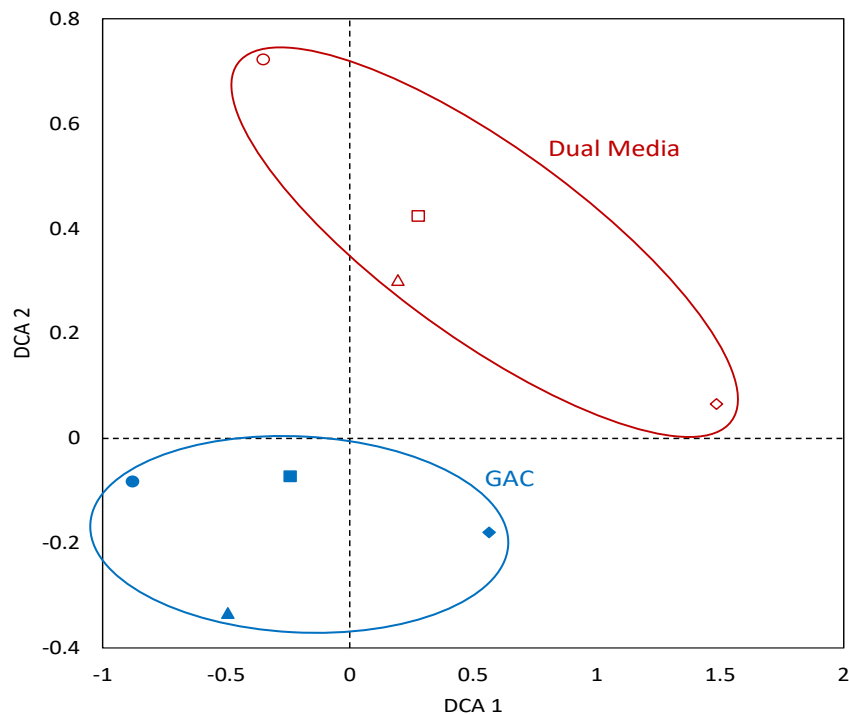


Canonical Correlation Analysis Revealed Putative CEC-degrading Species at the Optimal Operation Conditions



Filter Media Governs the Acclimated Microbial Communities in the BAFs

○ Dual Media w/ O₃ 18 min △ Dual Media w/ O₃ 10 min □ Dual Media w/o O₃ 18 min ◇ Dual Media w/o O₃ 10 min
 ● GAC w/ O₃ 18 min ▲ GAC w/ O₃ 10 min ■ GAC w/o O₃ 18 min ◆ GAC w/o O₃ 10 min



Zhang et al., Sci. Total Environ. 2018.

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