Advanced Water Treatment for Direct Potable Reuse

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Introduction

Direct potable reuse (DPR)

- Becoming more desirable[1]
- DPR is the treatment of wastewater to drinking water quality without an environmental buffer, such as a river or groundwater aquifer.[1]
- Conventional potable reuse trains consist of microfiltration (MF), reverse osmosis (RO) and advanced oxidation processes (AOPs).[2]

RO Limitations

- Membrane fouling
- Concentrate disposal
- Operation costs
- Necessary pre-treatment of the influent water

Proposed Treatment Train

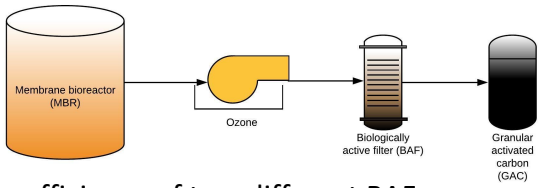
- Membrane bioreactor (MBR) permeate is treated by ozone (O_3)/ granular activated carbon (GAC) - biologically activated filtration (BAF) system
- O_3 makes organic compounds more biodegradable during BAF post-treatment.[2]
- GAC can be utilized as a final polishing step that absorbs the rest of the organic carbon in the water.[2]

Difference Between BAF and GAC

- BAFs are seeded and aerated in order to promote microbial growth on the GAC
  - Allows for biodegradation
- GAC provides absorptive removal of organic compounds

Objectives

- Get ozone O_3/ GAC - BAF system up and running



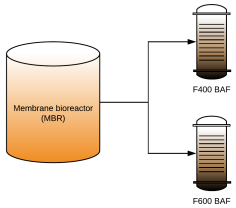
- Evaluate efficiency of two different BAFs
  - F400 GAC
  - F600 GAC

Materials

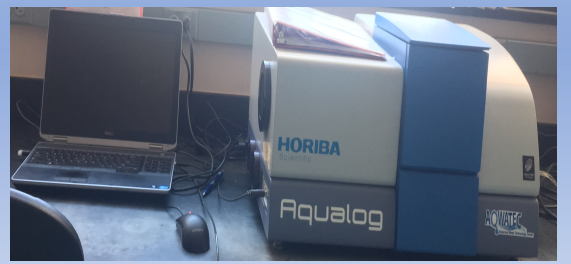
- Wastewater was obtained from a 250-student apartment complex at the Colorado School of Mines campus in Golden, Colorado.
- The following machines were used for the analytical methods:
  - TOC 500, Shimadzu Corp., Kyoto, Japan
  - DU 800 UV Spectrometer, Beckman Coulter, Brea, CA
  - FluoroMax-4, HORIBA Jobin Yvon, Edison, NJ

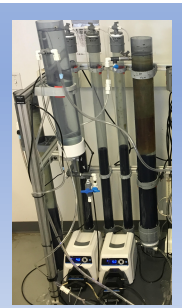
Methods

1. Wastewater was treated in a membrane bioreactor (MBR) then split between the two BAFs.



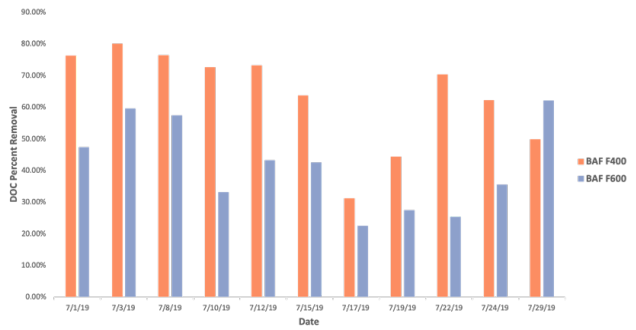
2. The removal of organic material by the BAFs was determined by three different analytical methods:
   - Dissolved organic carbon (DOC) measurements
   - Ultraviolet (UV) 254-wavelength absorbance
   - Fluorescence.
3. Samples were collected three times a week – Monday, Wednesday and Friday.
4. They were filtered with a 0.45µm filter prior to analysis.
5. The samples for DOC were acidified to a pH of 2.
6. The UV254 and fluorescence samples were placed in a sterilized and acid rinsed cuvette.





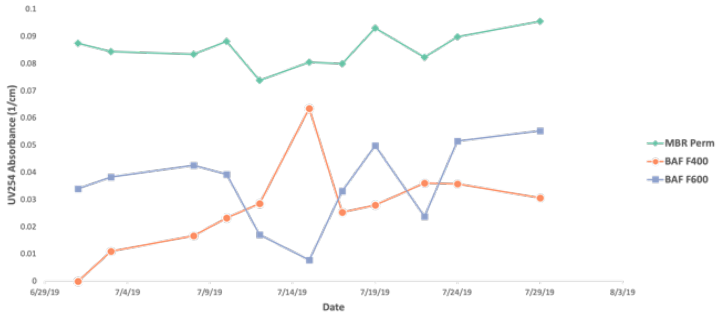
Results and Discussion

Figure 1: DOC Percent Removal of F400 and F600 GAC on the Corresponding Date



The F400 BAF was hypothesized to have better removal of DOC than the F600, because the GAC is not fully exhausted; removal was likely due to adsorption. Also hypothesized is that the F600 BAF had a higher removal of DOC on the last day samples were collected because students had started returning to the school and the wastewater characteristics changed.

Figure 2: UV254 Absorbance of F400 and F600 BAFs on the Corresponding Date



The instability of the UV254 absorbance values indicate that the BAFs may require more time until they reach a steady state condition. However, the results also indicate that there is significant removal of organic constituents during BAF.

Figure 3: Fluorescence contour plot for 7/1/2019

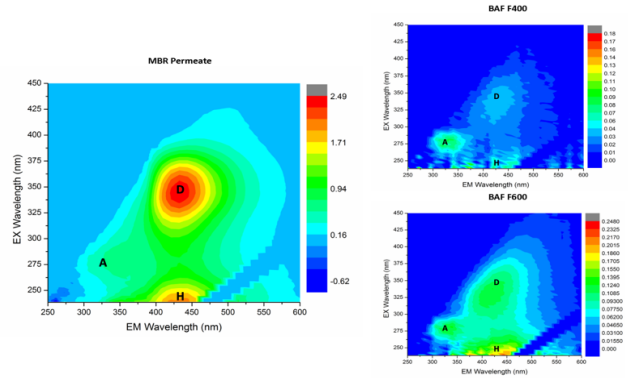
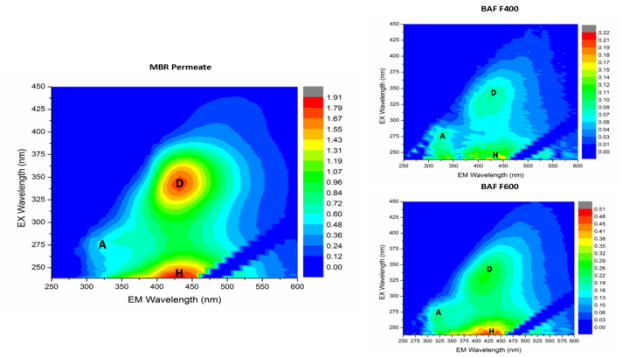


Figure 4: Fluorescence contour plots for 7/24/2019



Past studies have showed the peaks in Figures 3 and 4 represent different compounds; Peak A represents aromatic amino compounds (primarily tryophan and/or tyrosine), Peak H represents dissolved humic substances, Peak D represents a secondary humic substances of terrestrially derived dissolved organic matter (DOM); all three of which represent organic matter.[3] It is noted that for both days, the F400 BAF was more efficient at removing dissolved humic substances and secondary humic substances of terrestrially DOM than the F600 BAF was. However, neither was very efficient at removing the aromatic amino compounds.

Future Work

The removal of contaminants of emerging concern (CECs), primarily pharmaceuticals, personal care products and urban pesticides, with the complete treatment train will be investigated. Because it is an alternative to RO based treatment trains and CECs are continuing to become a larger problem, it is important to evaluate and determine the effect this will have on water quality.

References

[1] Epa.gov. (2017). 2017 Potable Reuse Compendium. [online] Available at: https://www.epa.gov/sites/production/files/2018-01/documents/potablereusecompendium_2.pdf.

[2] Vatankhah, H., Szczuka, A., Mitch, W., Almaraz, N., Brannum, J., & Bellona, C. (2019). Evaluation of Enhanced Ozone-Biologically Active Filtration Treatment for the Removal of 1,4-Dioxane and Disinfection Byproduct Precursors from Wastewater Effluent. Environmental Science & Technology, 53(5), 2720-2730.

[3] Zepp, Sheldon, & Moran. (2004). Dissolved organic fluorophores in southeastern US coastal waters: Correction method for eliminating Rayleigh and Raman scattering peaks in excitation–emission matrices. *Marine Chemistry, 89*(1-4), 15-36.

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