# Advanced Water Treatment for Direct Potable Reuse

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## Introduction

Direct potable reuse (DPR) is becoming more desirable; the desire is dependent on the presence of the following local factors: water supply stress, groundwater withdrawal impacts, water quality challenges associated with conventional water sources, increasing coat of limitations on discharges, opportunities for non-potable reuse are limited.[1] Potable water reuse is the process in which wastewater is treated until it becomes drinking water; direct potable reuse 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] However, there are many limitations to RO-based treatment trains – including membrane fouling, concentrate disposal, operation costs and the necessary pre-treatment of the influent water. Therefore, there has been discussion of alternative treatment technologies, such as ozonation and biologically active filter (BAF).[2] The proposed treatment train that will be evaluated consists of ozone/granular activated carbon (GAC)-BAF. Figure 1, below, shows the proposed treatment train.

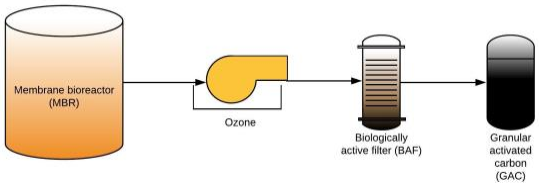


**Figure 1: Proposed treatment train**

Ozone is utilized to make organic compounds more biodegradable before they go through the BAF, and GAC can be utilized as a final polishing step that absorbs the rest of the organic carbon in the water.[2] The difference between the GAC and BAF process is that the BAFs are seeded and aerated in order to promote microbial growth on the GAC so that the GAC not only provides absorption but also biodegradation.

The main objective of this research project is to evaluate and compare two different biologically active filters (BAFs) based on their efficiency and effectiveness on removing organics. However, the current stage of the project only consists of the MBR permeate to run through two BAFs. The difference between the BAFs is the type of GAC that was acclimated before use and the acclimation method. The F600 GAC (Calgon) was acclimated for 3 months with activated sludge and in service longer, whereas the F400 GAC (Calgon) was acclimated with MBR permeate and not in service as long.

## Materials and Methods

The wastewater was obtained from a 250-student apartment complex up the street from the Colorado School of Mines campus in Golden, Colorado. It was treated in a membrane bioreactor (MBR) then split between the two BAFs.

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

## Results and Discussion

Figure 2 represents the DOC removal of each BAF with respect to the DOC concentration of the MBR permeate.

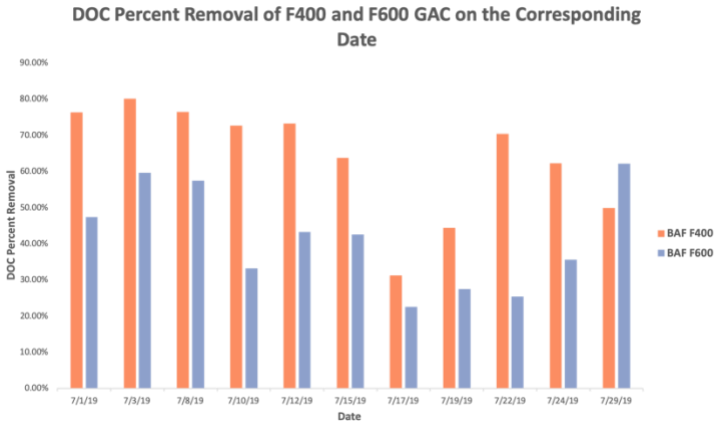


**Figure 2: DOC removal for BAFs**

The F400 BAF was hypothesized to have better removal of DOC than the F600, because the GAC was not fully exhausted; removal was likely due to adsorption. It is also hypothesized 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 3 summarizes the UV254 absorbance and removal results obtained for each corresponding date.

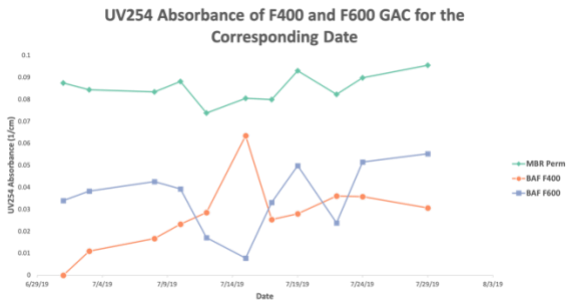


**Figure 3: UV254 Absorbance for MBR permeate and BAFs**

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 removal of organics.

Fluorescence is useful in determining the removal of relative fractions of organic carbon. Past studies have showed the peaks 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 organics.[3] Figures 5 and 6 represent the fluorescence contour plots that were obtained

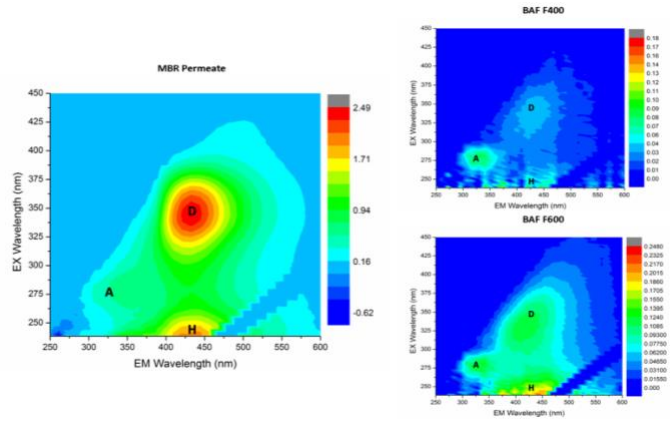


**Figure 4: Fluorescence contour plot for 7/1/2019, the first day samples were taken**

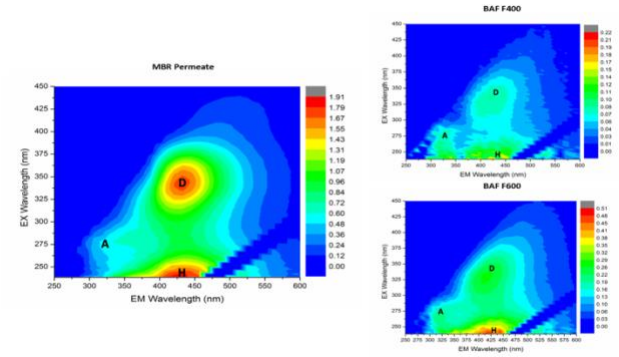


**Figure 5: Fluorescence contour plots for 7/24/2019**

It is noted that for 7/1 and 7/24 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. However on 7/24, the BAF F400 was less efficient than it was on 7/1

## Future Work

The removal of contaminants of emerging concern (CECs), primarily pharmaceuticals, personal care products and urban pesticides, with the complete treatment train (Figure 1) should 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

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[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.

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