Comparison of Pathogen Removal in Wastewater Treatment: Algal-Based Photobioreactor vs. Existing Treatment

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Wastewater Treatment is known to be an energy-intensive process. In Wastewater Treatment, "aeration is the most energy-intensive operation, amounting to 45-75% of plant energy costs" (Rosso, Stenstrom, & Larson, 2008). At New Mexico State University, an algal-based photobioreactor (PBR) has been developed that hopes to eliminate the need for aeration and produce beneficial by-products in the same process.

The proposed PBR system is used as a batch reactor with a capacity of 700 liters that treats wastewater with cultivated algae inside of a transparent bioreactor. The influent used for the PBR system is the effluent from the primary sedimentation basin at the Las Cruces Wastewater Treatment Plant (LCWTP). After the primary sedimentation effluent is inserted into the PBR system, sulfuric acid is added to drop the pH to 4.0. Lowering the pH of the wastewater is necessary as the algal species used in this project, *Galdieria sulphuraria*, is an extremophile that prefers a pH of 4.0, and a temperature of 45-50°C.

Due to the low pH conditions, it is hypothesized that the PBR system can remove human-bacterial pathogens from wastewater as pathogens tend to prefer neutral pH conditions. Thus, giving the algae a competitive advantage within the PBR. The purpose of this study is to determine the efficacy of the PBR system at removing pathogens from wastewater, and how this system's ability to remove pathogens compares to existing treatment techniques.

In order to test our hypothesis, membrane filtering, gel electrophoresis and qPCR were performed for three samples from the LCWTP (primary sedimentation effluent, trickling filter effluent, and secondary sedimentation effluent) and 6 samples from the PBR (PBR mixture directly after mixing, and PBR mixtures after the following days had passed: 1, 2, 3, 4, and 5). The samples from the LCWTP were used to represent existing treatment.

The purpose for membrane filtering was to gain a general understanding of pathogen concentrations at each of the sampling locations. Secondly, Gel electrophoresis was performed with hopes to identify which pathogen species are present within each sample. Lastly, qPCR was hoped to provide precise results to show not only which species were present at each of the sampling locations, but also how much of each species was present.

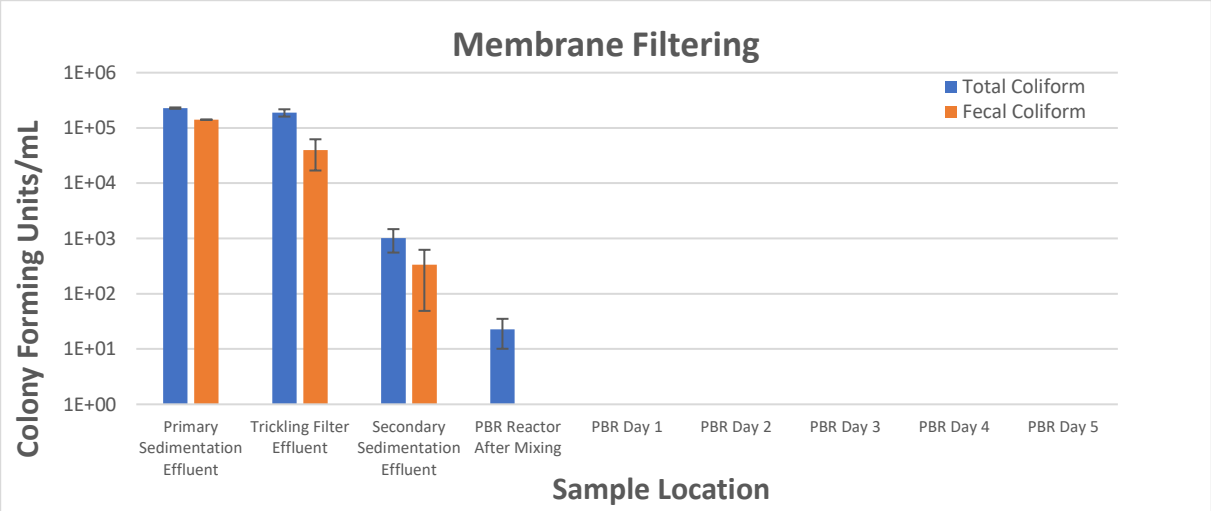

Figure 1. Fecal and total coliform counts from membrane filtering method

The results found from the membrane filtering method, shown in figure 1, indicate that the PBR system was effective at removing both total and fecal coliform from the wastewater. Even after secondary sedimentation, which is the last process prior to disinfection at the LCWTP, coliform totals were significantly higher than coliform totals after treatment by the PBR system. Interestingly, fecal coliform was removed from the system just after mixing the reactor. Also of note, both total and fecal coliform were removed just after one day of treatment. The results given by the membrane filtration method indicate that pathogens may be inactivated by the PBR system, however these results do not provide precise quantitative results nor do they provide insight as to which species can or cannot be removed.

The following method, gel electrophoresis, couldn't provide insight as to which pathogen species were present within each sample due to an excessive amount of primer added prior to PCR. However, gel electrophoresis did agree that total bacteria was present in the primary sedimentation effluent.

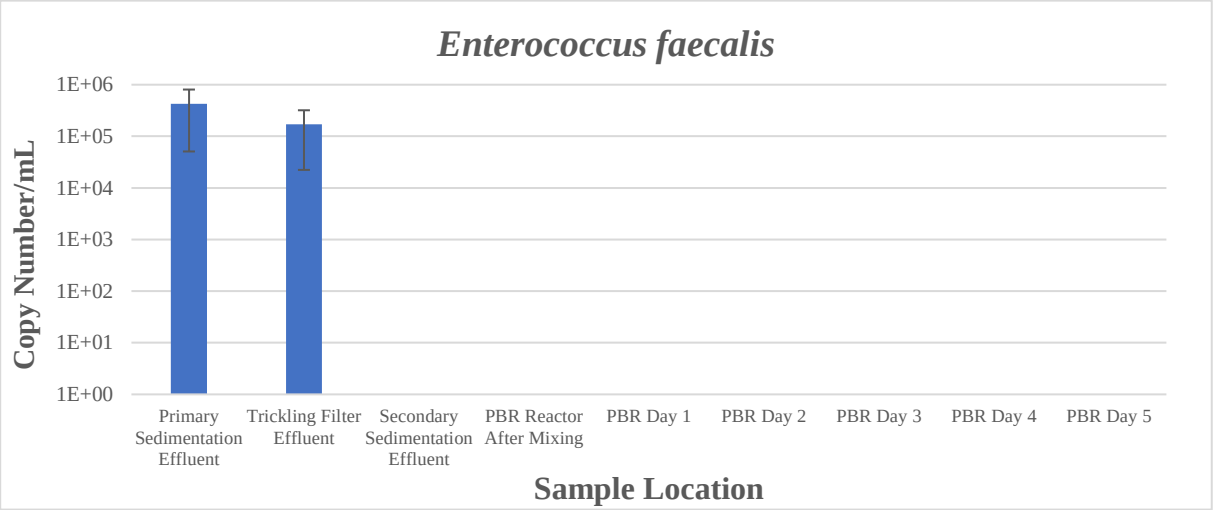

Figure 2. Copy number/mL of *Enterococcus faecalis* from qPCR

The results from qPCR for *Enterococcus faecalis* are shown in figure 2. These results show that the PBR was fully capable of removing *Enterococcus faecalis* from the wastewater even just after mixing the wastewater and algae inside the PBR. Furthermore, the LCWTP was also successful in removing *Enterococcus faecalis* from the system following secondary sedimentation.

Other species had been tested with qPCR, but only the tests for *Enterococcus faecalis, Salmonella enterica,* and the algal species, *Galdieria sulphuraria,* yielded successful results to draw conclusions from. The pathogen species *Salmonella enterica* was not present in any of the samples, including the primary sedimentation effluent. This likely means that *Salmonella enterica* was not present in the influent wastewater to the Las Cruces Wastewater Treatment Plant. The qPCR test for Galdieria sulphuraria does not provide any insight into pathogen removal, however it was found that the concentration of the algal species increases gradually throughout PBR treatment.

In conclusion, the PBR system can remove pathogens from wastewater, yet the efficacy of the PBR at removing pathogens is unknown. However, further qPCR tests could provide insight into the system's true effectiveness at inactivating pathogens. Also, it is fair to conclude that pathogens are removed by the PBR system in less than 1 day of treatment. However, the optimal contact time is still unknown.

Works Cited

Rosso, D., Stenstrom, M.K., Larson, L.E. (2008). Aeration of large-scale municipal wastewater treatment plants: state of the art. *Water Science Technology.*