Introduction

As water scarcity issues become more relevant in the United States efforts are being made towards the design and implementation of decentralized urban wastewater treatment centers. One system that is suspected of being capable of easing water scarcity issues is membrane bioreactors (MBRs). The MBRs ability to tailor water for specific uses and its ability to recycle water without polluting or degrading ground water resources is making these types of systems appealing to engineers, scientists, legislators and community members.

Reuse (turf grass and algae)

A major goal of the ReNUWIt ERC is the development of tailored wastewater treatment centers. These systems allow large consumers of water resources to purchase tailored water for industrial and recreational (golf courses) purposes. This will help ease the monetary demand of both the consumers and producers of tailored water.

Figure 1-Mines Park Turf Grass Site (Purple-MBR effluent/White- Potable)

The MBR located at Colorado School of Mines uses tailored effluent for the irrigation of a turf grass site (fig.1) as well as for the production of biomass in the form of algae (fig.2). The MBR produces effluent based on current research demands. When the demand is for potable water the effluent must be dosed with nitrogen to create a synthetic wastewater which can then be applied to the irrigation plots and algae ponds.

Figure 2-Mines Park Algae Ponds (Left-MBR effluent Right- Potable with nutrients)

When tailored effluent is used for irrigation there is concern for how the nutrients will be transported through the soil and possibly into ground water. Therefore, efforts are being made to determine exactly how nutrients are taken up by irrigated plots to help determine optimal levels of nitrogen and other nutrients in the effluent. This is a very laborious task as holes must be drilled into the soil which contains many rocks at the Mines Park location. Once holes were dug, samples were collected at very depths and mixed in an attempt to make a homogenous sample for testing. The leachate samples were analyzed in the lab at Mines Park using Hach Testing Kits while the soil samples were sent to a third party lab for testing to keep analysis consistent. Plots were generated with the leachate samples showing nitrogen concentrations as a function of depth.

The growth in the algae ponds were analyzed on a daily basis for approximately 2 weeks. Samples were taken daily and processed for optical density and total suspended solids (TSS). In an attempt to normalize results plots were generated showing mass as a function of date (figure3).

Energy Assessment

An important aspect of MBR design and operation is proper aeration (Judd, 2006). Aeration plays a major role in the biological and chemical processes required to treat wastewater to appropriate levels. This process requires the bulk of the required energy inputs for MBRs (Tchobanoglous et al, 2003).

There are two types of diffusers commonly used in aeration; fine bubble porous diffusers and coarse bubble non-porous diffusers. The geometry of the bubbles produced by the fine bubble diffusers allow for a larger amount of the oxygen in the air to be transferred into the water. However, pushing the air through a porous material will require a larger power demand. A computer model was developed to better understand the tradeoffs between oxygen transfer efficiency and power consumption.

Results

The algae being cultivated in the pond with optimal nutrient levels produced twice as much biomass than the pond with synthetic wastewater (figure 3). Although algae can grow well in an effluent medium it will not produce as much biomass as a culture growing in optimal conditions. However, depending on the purpose for algae cultivation growing cultures in a tailored MBR effluent could produce a sufficient amount of biomass and reduce the amount of required nutrient inputs.

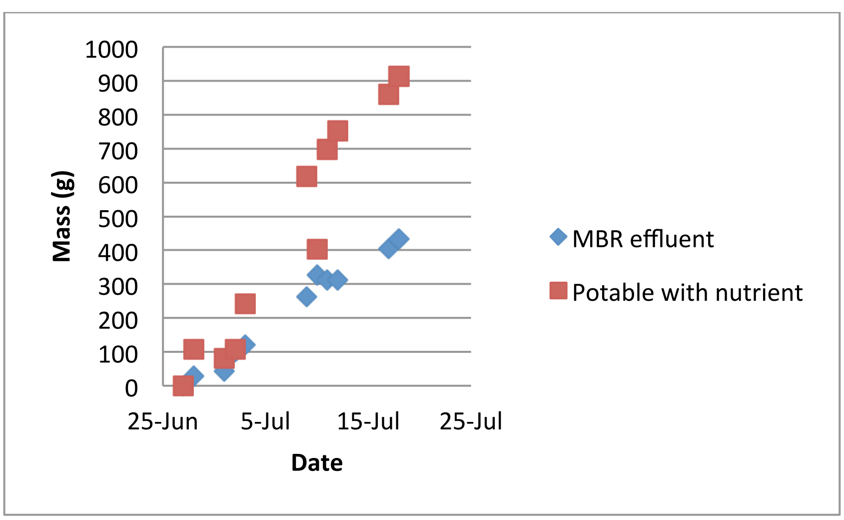

Figure 3- Algae Growth, Mass Vs Date

As shown in the plots below, switching to a fine bubble porous diffuser will result in an 89% reduction in the power requirements for COD (figure 3) and an 86% reduction in the power requirements for the nitrification of ammonia (figure 4).

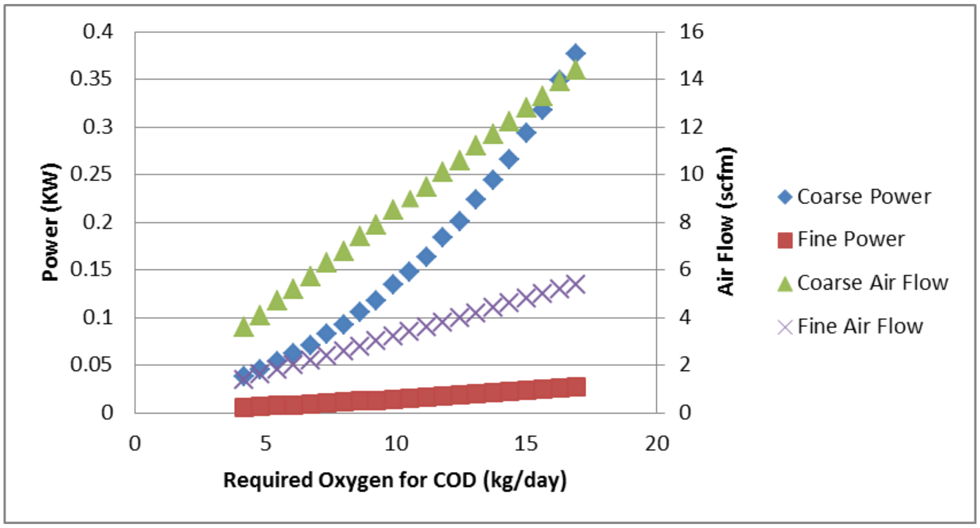

Figure 4-Power and Air Flow Vs Required Oxygen for COD

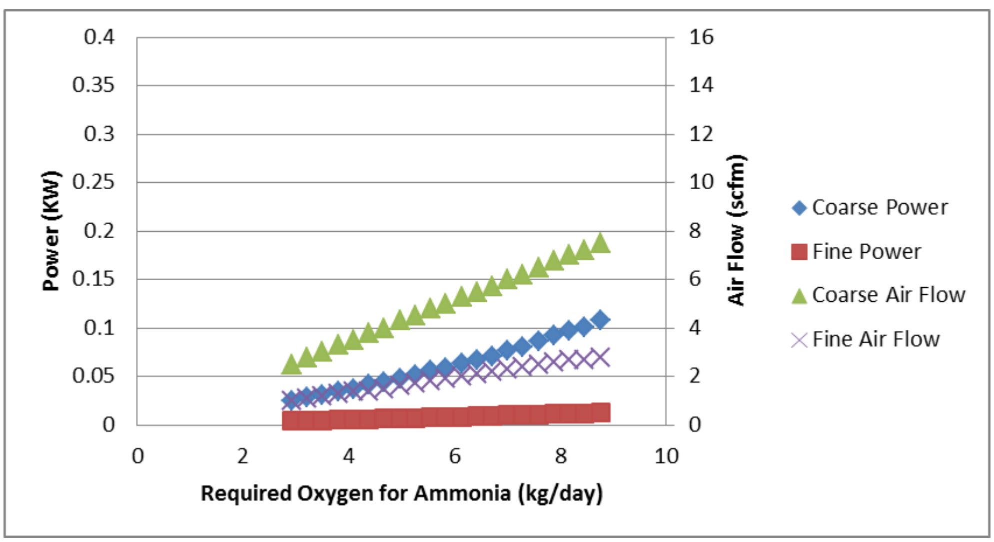

Figure 5- Power and Air Flow Vs Oxygen required for the nitrification of ammonia

Conclusions

The fine bubble porous diffusers showed a significantly lower power demand for meeting an equivalent required oxygen demand for both COD and ammonia nitrification. The model also shows that as the required oxygen increases over the range of interest the percent change in power will also increase. That is, as the flow rate increases so will the difference in the power requirement. Therefore, in order to save energy the Mines Park Wastewater Treatment Facility is encouraged to switch to an aeration system that utilizes fine bubble porous diffusers.

References

Judd, Simon, and Claire Judd. The MBR Book: Principles and Applications of Membrane Bioreactors in Water and Wastewater Treatment. Amsterdam: Elsevier, 2006. Print.

Tchobanoglous, George, Franklin L. Burton, and H. David. Stensel. "Physical Unit Operations/Aeration Systems." Wastewater Engineering: Treatment and Reuse. 4th ed. Boston: McGraw-Hill, 2003. 311-471. Print.