PHOSPHOROUS REMOVAL PILOT TESTING:

COMPARING MICROFILTRATION AND CLOTH-MEDIA FILTRATION TECHNOLOGIES

Adam Evans
HDR Engineering, Inc.
17111 Preston Road
Dallas, TX 75248

ABSTRACT

Microfiltration and cloth-media filtration were pilot tested for plant expansion and water supply augmentation purposes. The performance of the pilot units was assessed by evaluating key influent and effluent data, including suspended solids, turbidity, total phosphorous, hydraulic loading rate, flux, and chemical addition. Results showed that one of the cloth-media filters, and both of the microfiltration membranes tested could meet all forecasted requirements for augmentation, achieving lower than 0.5 mg/L total phosphorous on the cloth-media filter, and 0.3 mg/L on both microfilters. The microfiltration membranes were tested on both secondary effluent and filtered effluent. Sustainable flux rates on filtered effluent were approximately 40% higher than secondary effluent.

KEYWORDS

reuse, water supply augmentation, microfiltration, cloth-media filtration

INTRODUCTION AND OVERVIEW

A recent long-range water-planning study concluded that Dallas Water Utilities (DWU) will need to reuse 120 mgd of treated wastewater effluent. It is envisioned that 60 mgd of this will come from the Dallas Southside Wastewater Treatment Plant (Southside), and this treated wastewater will be used to augment Lake Ray Hubbard, a source of raw drinking water for DWU.

The Phase IV Expansion of Southside will increase the plant's average daily flow capacity by 30 million gallons per day (mgd) – from approximately 110 to 140 mgd. Water used for lake augmentation must meet stringent nitrogen and phosphorus limits, and this expansion provides a timely opportunity to produce effluent quality suitable for this reuse option. Phases I through III at Southside provide advanced treatment with nitrogen removal and effluent filtration. To achieve the necessary quality for lake augmentation, cloth-media filtration is being considered for Phase IV, and microfiltration is being considered for use throughout all four Phases of the plant to provide polishing for phosphorus and pathogen removal.

Pilot testing occurred over an eight-month (approximately) period between November 2005 and June 2006. This period was selected because it included the time of year with the coldest wastewater and highest viscosities, and thereby established worst-case scenarios for hydraulic loading rates on the filters and membranes.

GOALS AND OBJECTIVES

The goals of the pilot study were to determine the basic design criteria for the wastewater treatment facility, to provide performance data, and to allow the Southside staff to become familiar with the technologies being considered. In particular, the study was to focus on the design flux rate for membrane filtration of both filtered effluent and secondary effluent, and on removal efficiencies of all technologies tested. Prior to testing, it was expected that sustainable flux rates of filtered effluent would be much higher than secondary effluent flux rates; but it was also possible that flux rates on secondary effluent would be high enough to warrant full-scale installation without filters.

METHODS

Four technologies were piloted as part of the project: two cloth-media filters, a pile-cloth type, and the other a thin polyester type (hereinafter referred to as CMF1 and CMF2, respectively); and two microfiltration membrane systems, a pressure type, and the other a submerged vacuum-type (hereinafter referred to as MF1 and MF2, respectively). These treatment technologies were selected for testing based on their solids removal and polishing capabilities, and for the fundamentally different approaches designed by two manufacturers of the same technology.

The testing facility, shown schematically in
Figure 1, allowed for multiple influent combinations for the microfilters. Under this arrangement, the microfilters could treat existing plant filter effluent (anthracite mono-media), secondary effluent, and pilot-scale cloth-media-filter effluent. Chemical addition was used upstream of the pilot units to precipitate phosphorous and enhance removal.

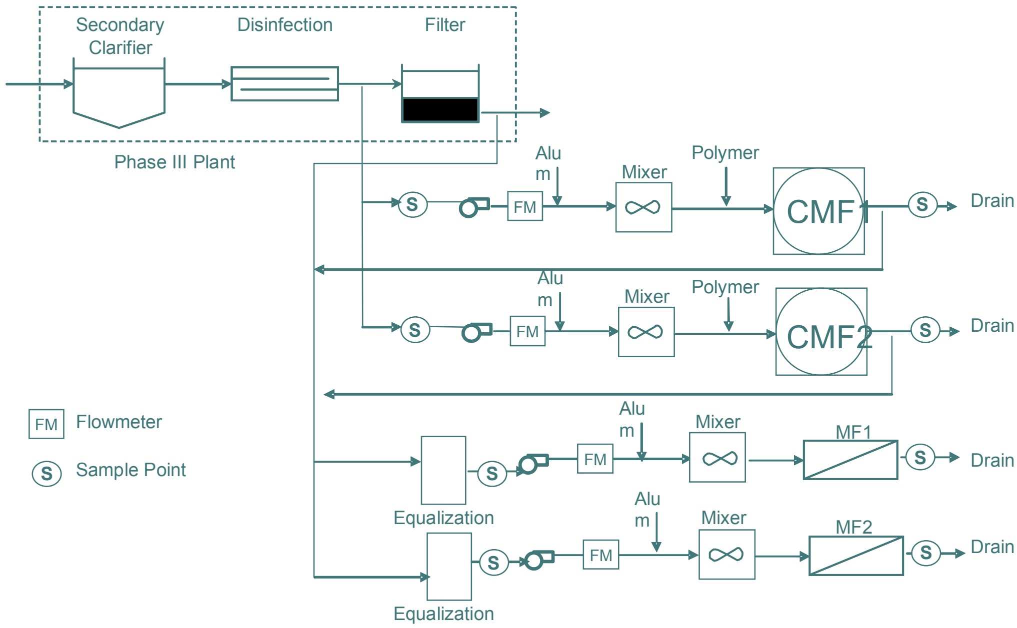

Figure 1 - Pilot Facility Schematic

STUDY PHASES

The pilot study commenced with a two-week jar testing phase to determine the appropriate amounts of coagulant and polymer to be used for nutrient polishing. Due to the clean secondary effluent at Southside, test results indicated that no chemical addition was necessary for enhanced solids removal. The use of coagulant actually increased the amount of solids in the samples by approximately 0.5 mg TSS per mg of chemical at low doses. Figure 2 shows solids removal results from the jar testing.

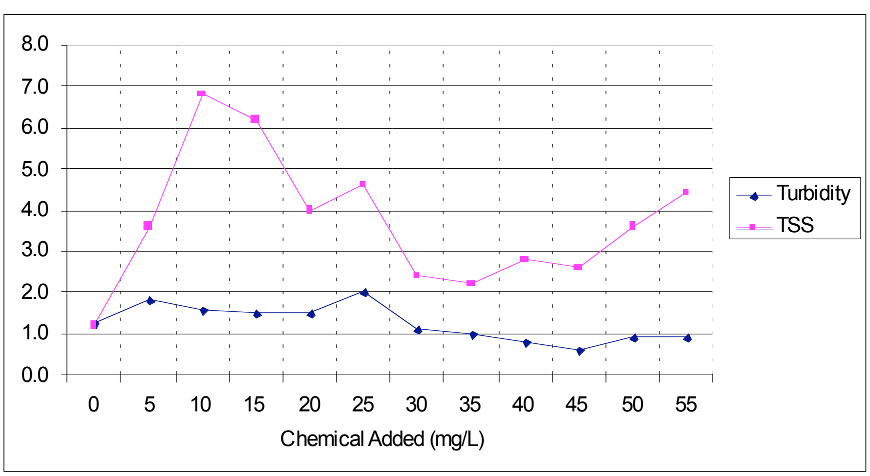

Figure 2 - Suspended Solids and Turbidity Results from Jar Testing

Although solids removal was not enhanced with the use of chemical addition, phosphorous removal was accomplished with a coagulant dose. Figure 3 shows phosphorous removal results from the jar testing.

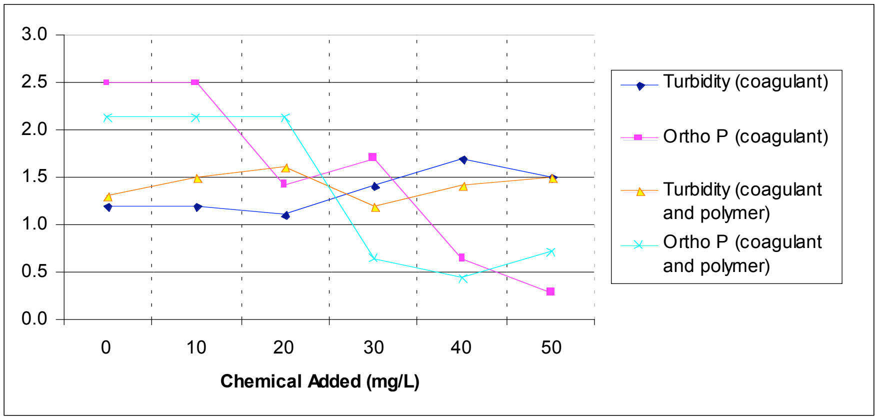

Figure 3 - Phosphorous and Turbidity Results from Jar Testing

Despite the lack of solids removal improvement, it was decided to test the pilot units at varying coagulant doses in an effort to better determine the effect that chemical addition would have on solids and phosphorous removal, as well as membrane flux rate. Table 1 summarizes the pilot study phases, and the purpose of each individual phase.

Table 1 - Pilot study phases and information

Category	**Pilot Unit Tested**	**Influent Process Stream**	**Duration**	**Purpose**
Phase I	Jar testing	Secondary and filtered effluents	2 weeks	Optimize chemical dosages
Phase II	Cloth-media filters	Secondary effluent	4 weeks	Basic design criteria and operator familiarity
	Microfilters	Filtered effluent		
Phase III	CMF2/MF1, CMF1/MF2	Secondary effluent and cloth-media filter effluent	2 weeks	Test compatibility of cloth-media filters w/ MF
Phase	CMF2/MF2,	Secondary effluent and	4 weeks	Compare results with

IV	CMF1/MF1	cloth-media filter effluent		Phase III
Phase V	Microfilters	Secondary effluent	4 months	Basic design criteria and operator familiarity

PILOT STUDY RESULTS

This section presents the results of the pilot study in two sections – cloth-media filters and microfilters.

Cloth-media Filters

The goal for the cloth-media filters was to remove solids to approximately 5 mg/L TSS and turbidity to 2 NTU. It was also desired to remove phosphorous to a level below 1.0 mg/L total phosphorous, with a preference for 0.5 mg/L to meet the projected requirement for lake augmentation. Both cloth-media filters tested performed well on suspended solids and turbidity removal; however, CMF2 struggled to meet the phosphorous removal goals. The manufacturer of this filter indicated that a different disk and media design may perform better for phosphorous removal; the arrangement used in this pilot study was more suited for solids removal.

The secondary effluent being filtered had a very high level of dissolved phosphorous, which required a high dose of chemical coagulant to precipitate the phosphorous. The flow design and the media used by the CMF2 unit could not handle a high dose of coagulant, and thus was only able to remove approximately 15% of the total phosphorous, most of which was not dissolved. The design of the CMF1 unit allowed it to handle high chemical and solids doses, and was able to precipitate a large percentage of the dissolved nutrient. Filtered effluent was consistently below the targeted 1.0 mg/L total phosphorous, and frequently achieved the preferred 0.5 mg/L with a large chemical and/or polymer dose. Figure 4 shows results from the CMF1 pilot unit.

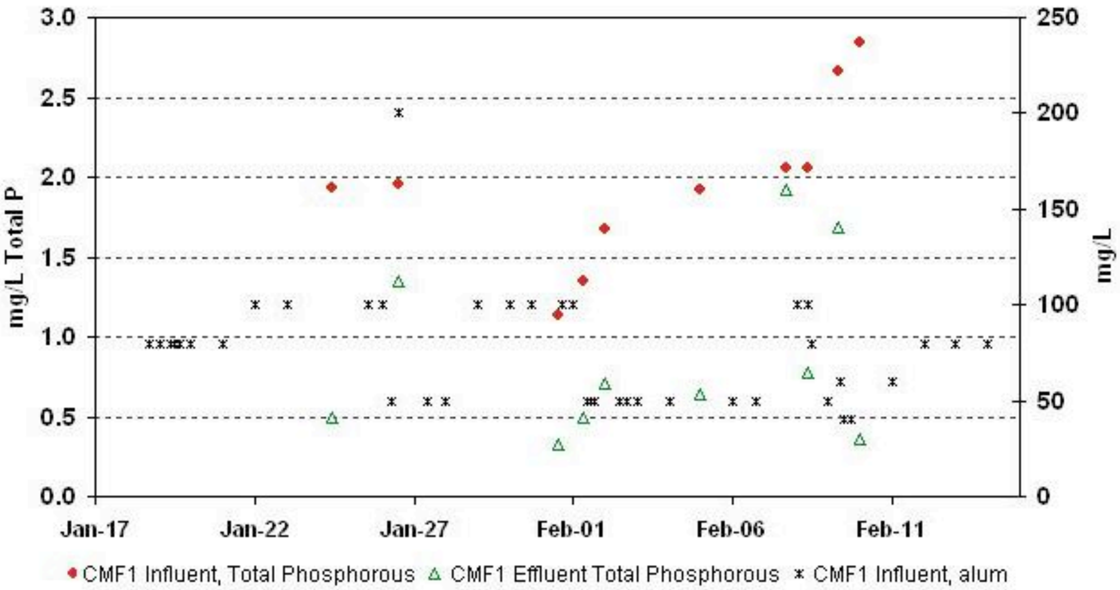

Figure 4 - Phosphorous Removal for CMF1 Pilot Unit

Microfilters

The goal of the microfiltration pilot units was to achieve an effluent quality suitable for lake augmentation. Though exact limits have not yet been established by TCEQ, it has been estimated that the requirements will be approximately:

- Suspended Solids: 5 mg/L TSS,
- Turbidity: 2 NTU, and
- Total Phosphorous: 0.5 mg/L.

In anticipation of future regulations that may be more stringent when lake augmentation becomes more common, it was decided to target a total phosphorous level of 0.1 mg/L. Both microfiltration pilot units performed well on solids and turbidity removal criteria, however, the targeted total phosphorous level was exceeded. With the use of alum, the microfilters were capable of keeping phosphorous levels below 0.5 mg/L total phosphorous, but rarely achieved a level below 0.3 mg/L. This is likely due to a relatively high phosphorous level in the feed water, and thus a requirement for a high dosage of coagulant.

Additionally, it was desired to compare sustainable flux rates of secondary effluent with that of filtered effluent. As hypothesized, flux rates for filtered effluent were substantially higher than those for secondary effluent. This disparity, though not the result of a single factor, can be heavily attributed to the difference in solids levels between the two test sources.

When the flux rates on secondary effluent were pushed beyond 45 gallons per square foot per day (gfd) on the MF1 unit, excessive backwashing, acid washing, and clean-in-place maintenance were needed to maintain a constant flow rate. Filtered effluent was consistently treated in the 60- to 65-gfd range. For the MF2 unit, secondary effluent was treated at an approximate flux rate of 25 gfd, and filtered effluent was treated at approximately 35 gfd. The disparity between flux rates for the two manufacturers is attributable to the fundamental differences in their filtration process. The pressure system, MF1, is able to maintain a higher transmembrane pressure than the vacuum system, MF2, and thus MF1 can push a higher flux rate across their membrane.

CONCLUSIONS

As expected before this study began, flux rates of secondary effluent are not comparable with those of filtered effluent. As such, it is not clear whether the use of microfiltration without effluent filters is a viable option. However, this study has shown that the use of cloth-media filtration for solids and phosphorous removal is a potential alternative to microfiltration for reuse situations.