TERTIARY CLOTH MEDIA FILTRATION WITHOUT ROTATING DISCS, VACUUM PUMPS OR SPRAY BARS

Authors

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Abstract

Fixed plate cloth media low-head filter systems offer Tertiary-Reuse quality treatment of wastewater from municipal & industrial secondary treatment processes while providing operators with several key advantages when compared to conventional sand filtration or disc type cloth media filters.

The advantages are the result of 2 important concepts utilized with fixed plate cloth filters; 1) the latest cloth media does not require excessive pressurized spray or backwash volume to clean and 2) already available differential head can be used to produce backwash flow.

Simple open-close pneumatic valves control the filtering and backwash operations. The position of the two valves associated with each filtering element determines the direction of flow. Therefore, NO pumps are needed to create backwash flow, which allows media panels to be fixed in place (instead of rotated past a stationary spray or suction manifold). Having fixed panels also allows them to be square or rectangular (vs. circular) easing manufacture, installation, removal, and maintenance, while maximizing treatment area within the tankage footprint.

100% acrylic filtering media is fixed within stainless steel elements which remain static during all operations. This significantly limits mechanical wear and maintenance. The static plate design is also very compact compared to many types of granular media or tertiary filters, due to the ability of the cloth media to be placed vertically, as opposed large flat sand beds. Cloth media also has a significantly higher throughput capacity than granular media, which further helps to reduce overall tankage size and footprint.

Fixed Plate cloth filters operate using gravity, requiring only small water level differential or head to push water through the filter cloth, making it ideally suited for treatment facilities located in low lying areas or where available gravity head is limited.

These advantages all combine to provide a tertiary treatment system which is easy to use, easy to maintain, inexpensive to purchase and operate, and robust enough to produce re-use quality effluent over a wide range of treatment applications.

Introduction

North Carolina needs filtration. Specifically tertiary filtration to reduce effluent turbidity and suspended solids in discharge from a diverse range of treatment and secondary processes utilized throughout the state. The applications are wide ranging, from protecting sensitive fishing streams near a Youth Camp in the Smoky Mountains to treating discharge from coastal development into sensitive coastal waters on Emerald Isle. Tight limits on effluent turbidity and suspended solids have prompted local officials, municipalities, developers and contractors to reconsider their choices regarding conservation, reuse, & wastewater treatment options.

It was this increased awareness and regulation that has prompted municipalities & local developers, along with the engineering community in NC, to include tertiary cloth media filtration as part of new and upgraded wastewater collection & treatment systems in order to protect these vital waterways and discharges.

Use and acceptance of cloth media systems for tertiary filtration has been wide-spread in NC as regulations & limits for effluent turbidity and suspended solids discharge have become more strimgent. The benefits of cloth media filtration systems (including higher throughput, reduced footprint, and simplified media replacement) have allowed these types of systems to all but replace older-style traveling bridge sand filters or other granular media filtration options. Most cloth media filter systems, when combined with well-run secondary processes, have been proven to reduce effluent solids (TSS) and Turbidity (NTU) to very low levels including TSS consistently below 5mg/l and Turbidities <1.5 NTU. In some areas, including some industrial applications, this level of treatment would allow for discharge water to be reused or recycled instead of discharged, if the need existed.

However, up until recently, most cloth media filtration systems were mechanically very complex, using variations on the same concept: cloth media attached to rotating disks, which once dirtied need to be cleaned with combinations of pumped high-pressure spray, pumped vacuum or suction, or other mechanically intensive means. Rotating disks were often made up of multiple pie-shaped segments or oddly shaped polygonal sections to allow the cloth to rotate past stationary suction or spray manifolds. Also, disks were often attached to large drums or center-tubes, which had to be rotated using large drive-gears, chains, & drive-motors near the liquid surface.

These early cloth media systems also needed to be dewatered to inspect internal components, change cloth, and maintain internal components, which required redundant treatment units or effluent storage (or bypass) during routine maintenance activities. Early cloth media disk filter systems that required redundant units to provide consistent and continuous service were often expensive as a result.

In order to eliminate some of the expense, operational disadvantages, and maintenance associated with original ‘Disk’ type cloth media filter offerings, fixed plate or static plate cloth media filter systems were developed in Madison, WI in 2005.

Discussion

Fixed Plate Cloth Media - No Moving Parts – Reduced Redundancy

Fixed Plate cloth media filter systems offered several key advantages over existing rotating disk style cloth media filter options. First, rectangular media elements stay fixed in place during all operations (no moving parts), eliminating much of the internal mechanical complexity, maintenance and cost associated with typical disk type cloth filter. Fixed filter plate systems use available differential head to produce forward and backwash flow. Simple open-close pneumatic valves – operated by a small air compressor and simple controls - control the filtering and backwash operations and determine the direction of flow, eliminating the need for pumps, manifolds, and rotating disks. Since elements do not rotate, they can be square or rectangular (vs. circular) easing manufacture, installation, removal, and maintenance. Element frames & tankage are 100% stainless steel, further reducing internal maintenance.

Second, individual media elements can be isolated from the remainder of the incoming flow stream and removed from the system without disrupting flow to the remaining online elements (reduced redundancy). Multiple isolated media panels within each tank or concrete basin allows incoming water to continue to enter the filter system while individual filter elements are being backwashed or are removed from the system. Incoming water is filtered through remaining on-line filter elements with treated water continually replenishing the clean water reservoir or main tank area. This liquid level is maintained while individual elements are gravity backwashed. Each element is backwashed in sequence, allowing complete system backwash without discontinuing or diverting flow during the process. During the backwash, flow to only one element has to be discontinued. The filter at Bulverde has capacity for six media elements, only 1/6th of which would have to be off-line at any particular time, with the remaining 5/6th or 83% of the media area remaining online. By sizing the unit to handle design flows with 5 of 6 elements installed, one element can be removed from the flow stream without disruption to capacity, upstream processes, or influent treatment.

If periodic inspection of media is required, individual media elements can be isolated from the remaining elements and removed from the filter system for periodic inspection and media replacement, all while flow continues to online elements Internal components are modularized and integral to the media element (not attached to the tank), which allows all internal components for each element to be removed while flow continues to the other online filter elements. Elements can be removed, inspected and returned to service without decreasing system capacity or interrupting flow. All media within the system can be changed sequentially, while the remaining installed online elements treat the full design flow.

The fixed plate filter systems incorporate an ‘inside-out’ flow pattern which is operationally advantageous to those that utilize ‘outside-in’ flow (where solids collect on the external areas of the media elements). Fluidyne’s fixed plate filter trap solids and biological material on the inside of the media elements, with cleaned effluent occupying the majority of the main tankage volume. This provides several benefits including allowing the operator to readily see the quality of the effluent, cleaner operation, and reduced operator contact with collected biological solids. Also, since heavier solids settle to the bottom of the filter (which are then removed without additional equipment or pumps during the normal backwash stage), heavy solids never contact the cloth media or need to be ‘handled’. This eliminates the need for hopper bottoms or sludge collection manifolds at the bottom of the main tank.

Also, some ‘outside-in’ systems utilize mechanical spray bars for cleaning, which spray high pressure water from the outside into the filter media, forcing some solids through the cloth to the clean water or interior side of the cloth, contaminating the effluent. In these systems, a separate 'rinse' cycle is then required where filtered water is diverted for several minutes after a spray cycle. High pressure spray also damages the cloth media over time, enlarging the filter media openings and causing premature failure and replacement.

Finally, since the fixed plate filter systems use simple open-close pneumatic valves and compressed air to provide both fluid flow control and agitation of the media during the air scour assisted backwash, no other mechanical systems are necessary. This significantly limits the power input to the system (a small PLC to operate solenoids and a small 1-2 hp compressor which only runs during periodic backwash cycles) as well as mechanical wear items & required spare parts.

These advantages all combined to provide tertiary treatment that is easier to use & maintain, as well as inexpensive to purchase and operate, while still maintaining reuse quality discharge & effluent treatment.

Results

The first large-scale fixed plate cloth media filter was setup for testing at the 40 MGD Madison Metropolitan Sewerage District (MMSD) in summer 2006 and operated successfully through Nov 2007. The original fixed plate cloth media filter system consisted of a stainless steel tank containing four (4) rectangular, fixed cloth media elements each capable of treating 200,000gpd of secondary wastewater (0.8 MGD total). Secondary flow from one of nineteen MMSD clarifiers was diverted to the fixed plate cloth media system via a 600gpm self-priming pump, treated, then discharged back into the clarifier's effluent channel. The entire system was powered by a 1.9hp pneumatic compressor, which along with the pneumatic open/close valves, were the only mechanical moving components in the system.

Flow from the secondary clarifier was pumped to the filter during all phases of filtration and backwash. The filtered effluent that collected in the main reservoir proved to be adequate to produce sufficient hydraulic head to clean the cloth media during backwash operations. The air scour system properly supplemented the water only backwash and increased cleaning efficiency through added agitation, resulting in backwash efficiency as low as 3% of forward flow during the fall of 2007.

Although successful, winter conditions in WI prevented longer term testing of the full-scale unit outdoors. In 2009 a second smaller pilot-scale unit was developed for placement indoors, near MMSD's UV disinfection system. This smaller pilot-scale fixed plate cloth media filter system consisted of a stainless steel tank containing four (4) rectangular, fixed cloth media elements, each containing 1.5sf of media and capable of treating 5gpm of secondary wastewater (~30Kgpd total). Secondary flow was diverted from the UV distribution channel (prior to UV) treated, then discharged back into the UV channel downstream.

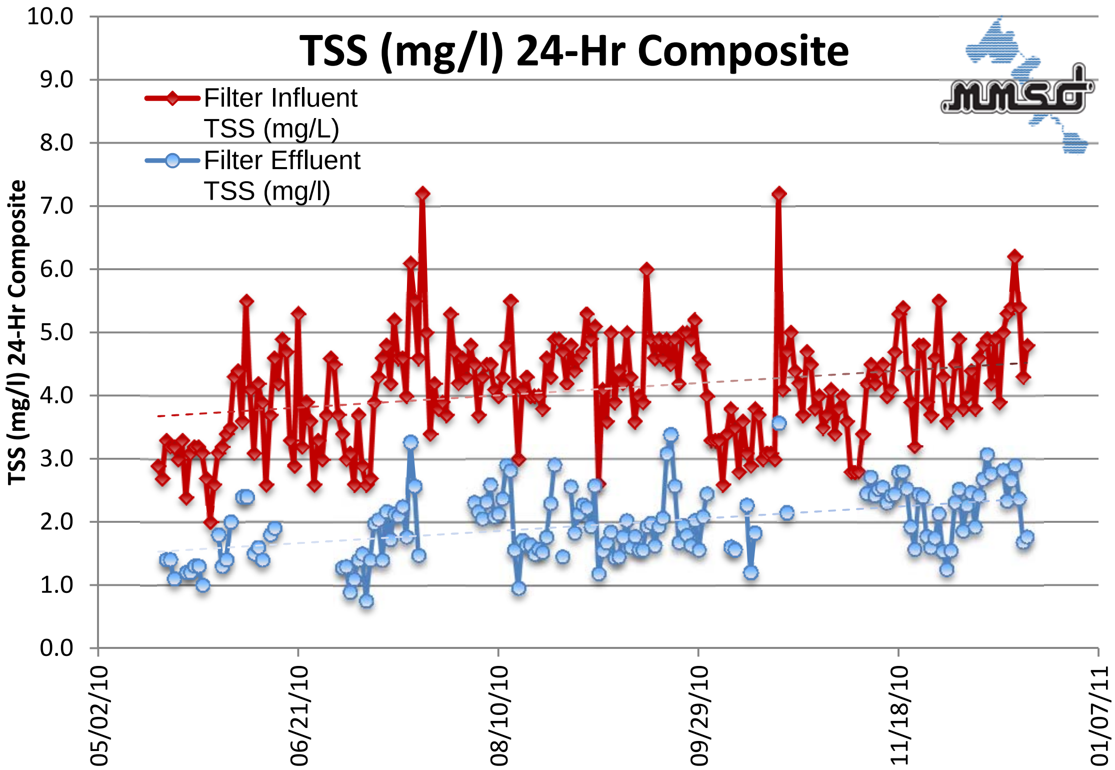

Figure 1 – influent vs. effluent TSS from MMSD Pilot-scale performance testing of fixed plate cloth media filter.

The entire system was powered by a 1hp pneumatic compressor, which again along with the pneumatic open/close valves, were the only mechanical moving components in the system. The pilot-scale unit was operated at MMSD for several months in 2009, then again from May to December of 2010 (7 months).

Performance was based on measurement of several key indicators including suspended solids (TSS) removal, turbidity (NTU) removal, and backwash efficiency. Daily Influent TSS fluctuated between 2-8mg/l with spikes up to 20 mg/l TSS periodically. Effluent TSS from the filter system was consistently below 3 mg/l with several grab samples below detection limits of 1.1 mg/l (See figure 1 for TSS data from MMSD-'10).

Influent turbidity, measured with a Hach 900C online turbidimeter, averages roughly 2 NTU, with spikes up to 5 NTU at times. Effluent NTU, measured concurrently with a second turbidimeter, averages below 1 NTU with multiple grab samples below 0.6NTU. Daily average NTU during all testing never exceeded 1.5NTU (See figure 2 for turbidity data from MMSD-'10).

Further testing and demonstration of both the full-scale & pilot-scale fixed plate cloth media filters were performed in 2008 through 2010 as part of a nationwide introduction to this new technology. Demonstrations were performed at several plants in WI, VA, NC, SC, TX, and KS.

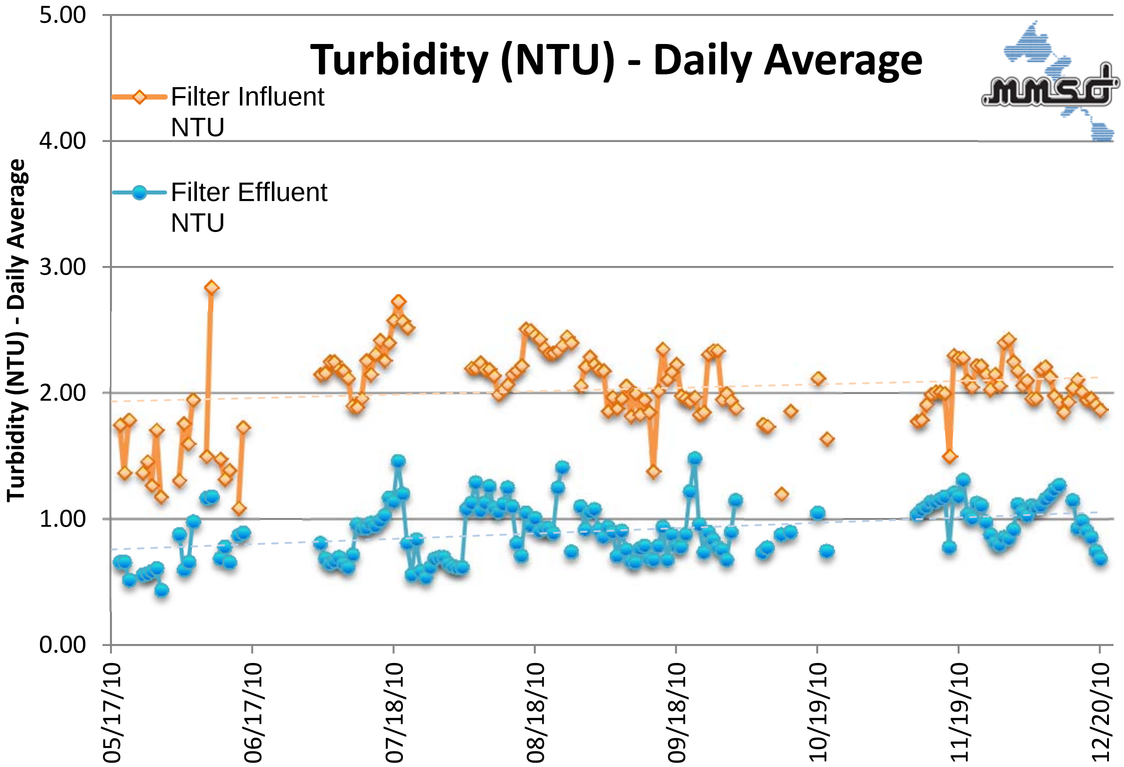

Figure 2 – influent vs. effluent Turbidity measured as NTU from MMSD Pilot-scale performance testing of fixed plate cloth media filter.

Side-by-side comparisons & Total P-Removal

Operators at the Jackson, WI WWTP wanted to compare the performance of the fixed plate cloth media system to their existing traveling bridge sand filters. Jackson had received new discharge permit requirements which significantly regulated the amount of phosphorous (P) they could discharge, which previously had not been a consideration. Jackson's operators & supervisors wanted to see how cloth media filters, and particularly fixed plate cloth media systems, compared to their existing traveling bridge filter (TBF) sand technology as they prepared to start design of tertiary system upgrades to achieve the new P discharge limits. The pilot-scale filter was setup along-side the existing TBF filters and influent from the TBF distribution channel was pumped to the filter at variable rates to mimic the hydraulic loading of the TBFs. Influent & Effluent suspended solids (TSS) as well as influent and effluent Total Phosphorous (TOT-P) were measured on a daily composite basis. Figures 3 & 4 show resultant TSS, & TOT-P data for the 45 day study period.

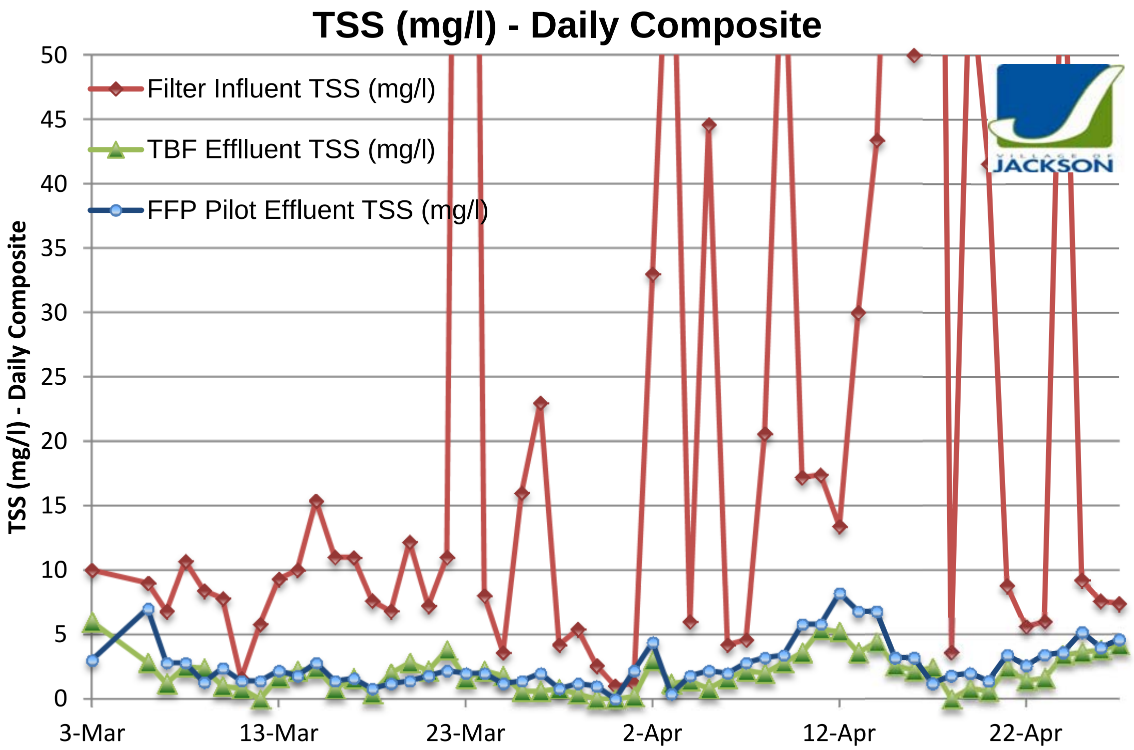

Figure 3 – influent vs. effluent Suspended Solids TSS (mg/l) from Jackson, WI Pilot-scale performance testing of fixed plate cloth media filter.

Part of the test procedure included experimental dosing of Alum as well as manipulation of the flow to the pilot to simulate various peaking conditions. Alum was purposely overdosed during testing to examine filter performance under upset conditions. Also, flow was increased from an average equivalent daily flow of 1.31MGD to over 5.25MGD during some periods. Also, the filter influent TSS exhibited extreme TSS fluctuations, with some composite samples in excess of 100 mg/l on several occasions.

Despite highly variable influent hydraulic, TSS solids, and alum overflow loadings, the fixed plate cloth media system performed on-par with the existing TBF system, but at an equivalent footprint of approximately 40%, meaning existing basins could be upgraded to over double the current filter throughput without significant changes to piping, hydraulics, or buildings. Furthermore, the fixed plate cloth media system exhibited no media fouling, plugging, or degradation throughout the 45 day test period despite extreme TSS solids loading fluctuations & heavy alum dosages. Backwash rates remained consistent between 4 - 6% during the entire test run.

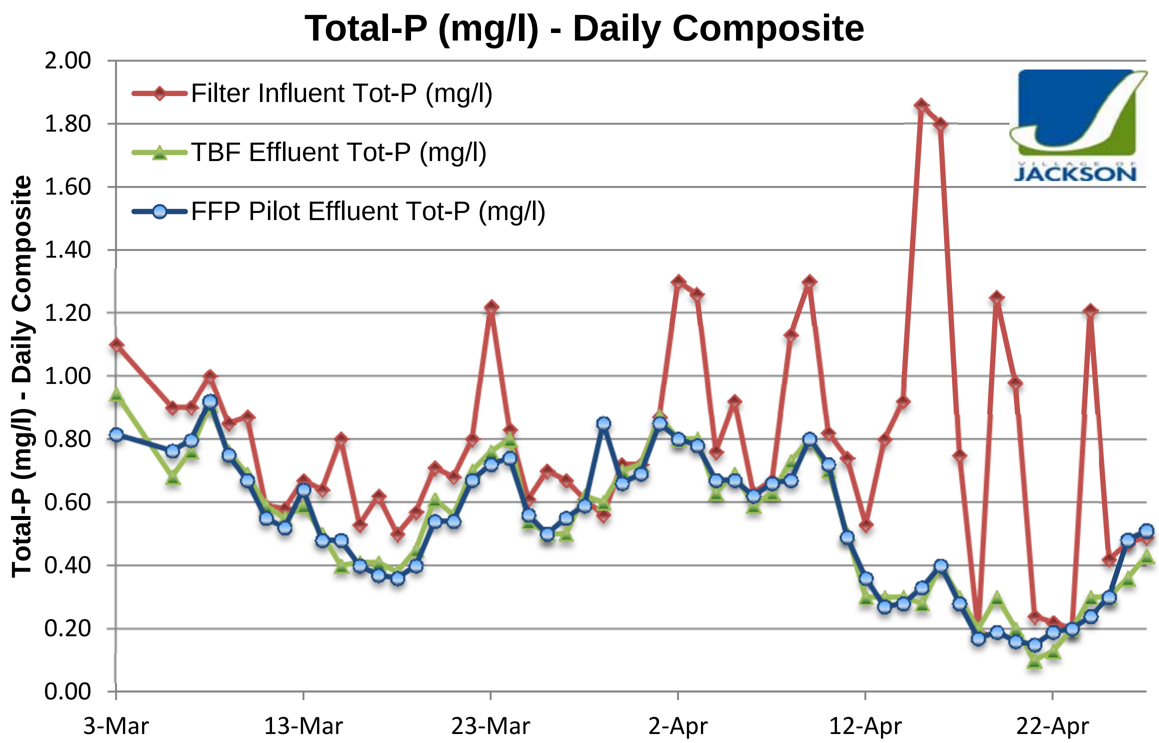

Figure 4 – influent vs. effluent Total Phosphorous (Tot-P, mg/l) from Jackson, WI Pilot-scale performance testing of fixed plate cloth media filter.

Conclusion

Fixed Plate systems installed in NC

In early 2009, the fixed plate filter technology was chosen as the preferred tertiary treatment technology to follow new secondary processes for 2 plant upgrades located on Emerald Isle, NC. Both plants have been operating since early 2010 and have continually produced & exceeded the effluent requirements required for coastal discharge. A third fixed plate cloth media filter was recently installed at a youth camp south of Asheville, NC and is expected to be operational in the spring of 2012. Fixed plate cloth media filters are currently operating successfully in several states nationwide, including TX, NC, CA, OH, WI, as well as Ontario, Canada.

Fixed Plates w/ air scour function as well as Disks, but without moving parts.

Although cloth media filtration and disk filtration are often thought of as synonymous, the development and successful implementation of fixed plate cloth media technology have shown that many of the inherent disadvantages & mechanical complexities of the original disk-type system can be eliminated without sacrificing efficiency or effluent treatment quality. By replacing rotating disks, vacuum manifolds, and spray bars with fixed media elements, hydraulic backwash, and air powered media agitation, much of the expense, operational complexity, and maintenance requirements can be removed from cloth media filtration.