Overcoming On-site Reuse Woes

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The buzz words "water reuse" are very pervasive in today's culture. Every day we receive newspapers, e-newsletters, and conference announcements that speak of drought, water shortages, global warming, discharge prohibitions, and conservation. One wastewater treatment plant at a Midwest municipality is responding to the water issues by reusing up to 2,000 gpm (gallons per minute) of effluent for various on-site applications. That amounts to 2.88 million gallons of water per day not being taken from drinking water resources.

Located along the banks of one of the largest tributaries to the Mississippi River, this 100 mgd (million gallons per day) wastewater treatment plant has a large demand for service water with low suspended solids. This water is needed for automatic cleaning devices on the primary bar screens located at the point where raw wastewater enters the treatment process (headworks). Wastewater happens; someone is flushing, showering, washing clothes, doing dishes, or gargling twenty-four hours a day. Therefore, the bar screen cleaning mechanism never rests. Belt presses used to dewater sludge are located at the other end of the treatment plant. These presses need a steady supply of spray water to keep the belts clean and porous. Pumps of various horsepower, configuration, and brand are scattered over the entire facility. Many of these have seals that must be drenched in water throughout their duty cycle. This water must be absent of any particulates that could cause scaring or erosion of shafts and seals. Service water at hose bibs and equipment wash stations need not utilize valuable potable water. Additionally, and somewhat unique to this facility, is the need for water to cool three large V-12 internal combustion engines that run off of methane gas generated in the anaerobic sludge digesters. These engines, in turn, drive large generators to produce much of the electrical power needed to run the wastewater treatment facility.

Many papers have been written about filtering effluent from a typical activated sludge treatment plant. In the activated sludge process, copious amounts of air are bubbled through a biological "soup" where microscopic organisms are intentionally grown to break down nutrients and chemical molecules and then assimilate them into body mass. In a later stage of treatment, some of these organisms release a portion of the nitrogen found in protein and ammonia back to the atmosphere through a process called denitrification when oxygen is deprived from the "soup." Other organisms simply die and their bodies, along with all the nutrients and chemicals they have used to grow, are collected at the bottom of a clarifier as a homogenous sludge that remains uniform over time.

Trickling Filter

While many municipalities utilize this activated sludge process, it is not the only treatment process available. This Mississippi River-located plant utilizes trickling filters which accomplish the same activity as the activated sludge process but in a less uniform manner. While activated sludge is made up of myriads of individual organisms that float around independent of other individuals, the trickling filter process produces large colonies of organisms that exist together in a bio-film mass attached to the filter's packing or media (originally trickling filters used smooth stones as media). This bio-film periodically sloughs off the media in large globs that do not settle as uniformly in a clarifier. Therefore, the suspended solids in the effluent from a trickling filter process tend to be more of a stringy, slimy, globular consistency than activated sludge effluent. Why is this distinction noteworthy? Few papers have been written on filtering effluent from the trickling filter process and fewer filter manufacturers have had experience with this effluent. The differences in the type of solids from these two processes raise performance issues worth investigating.

Filtration System

Various types of filters are available to remove solids from water or effluent as in this case. Bag or cartridge filters could be used but due to the high concentration of solids and large flow rates in this application, the operating costs to replace elements would be prohibitive. Granular media filters of various types have been used in similar applications for centuries, but they utilize a lot of real estate and generate enormous amounts of wastewater during their backwash cycles. Also, most of these filters have to be taken out of service during their extended backwash cycles, necessitating redundant units

This image shows one of several on-site trickling filters.

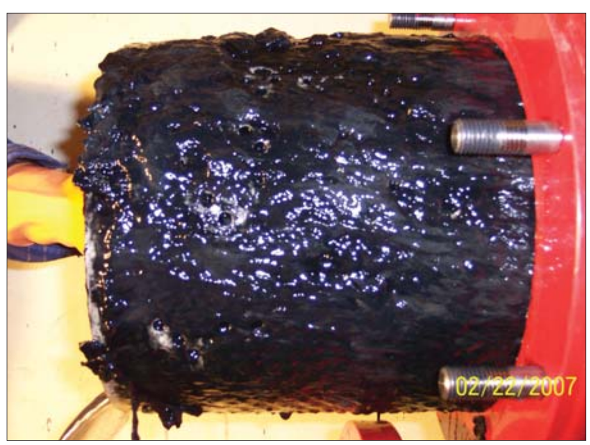
to maintain a continuous flow of clean water downstream. The large international engineering consulting firm charged with designing the expansion and new upgrades to this plant decided on automatic self-cleaning filters with 150 micron stainless steel weave-wire screens to make the effluent acceptable for reuse. Two 12-inch automatic self-cleaning filters were manifolded together to operate in parallel to provide sufficient capacity in a small area. The type of filters utilized automatically clean themselves by backwashing a few distinct dime-size areas of the screen and then moving those areas over the entire screen surface. This technology has two strong attributes: the entire screen area gets cleaned during each cleaning cycle and filters do not have to come off-line to clean; thereby, supplying filtered water downstream even while self-cleaning. Upon initial start-up of this filtration system a number of problems arose.

Installation Challenges

First, the microprocessor control box was installed on the wall with wiring in metal conduit before completely assembling the filters or studying the installation manual carefully. When final assembly of the filters was completed, a rigid filter component was in front of the control box door, preventing access to the controller for turning on power and adjusting variables. This was not a fatal error but was time consuming.

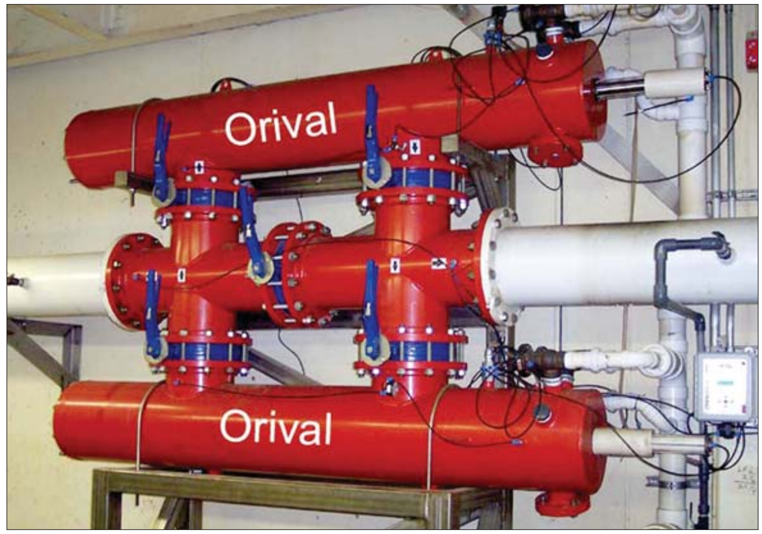
Next, the large dual filter system began to experience clogged screens in a matter of minutes after start-up. The filters automatically signal a cleaning cycle when either a 7 psi pressure differential is sensed across the filters or an adjustable preset timer has expired. As long as the differential pressure switch remains closed, the filter will repeat cleaning cycles until a pre-set number of cycles has been reached. Then the controller will shut down the cleaning process to prevent dumping too much water to drain and send a fault signal. This signal was being activated repeatedly. When the filters were opened for inspection the screens were found to be completely encased in a black, stringy, tarry thick sludge that even plugged the large 3/8-inch (9 mm) holes in the coarse protective screen. Further investigation showed a layer of sludge 12 to 15 inches thick had built up on the floor of the basin from which the pumps supplying the filters drew effluent. The vertical turbine pump inlets were located about 6 inches off the floor of the basin. *Screen filters are not sludge filters.* A vacuum truck was called to remove the sludge layer resulting in the filters operating for hours between cleaning cycles. Had the original engineers investigated a little further in the preliminary design stage they would have realized that an old coarse-screen continuous cleaning filter had been operating in this area for many years. But instead of flushing the debris it captured back to the headworks of the treatment plant, it dumped the debris back into the basin from which it received its effluent. Decades of accumulated solids had built up inside this basin, forming the dense sludge layer encountered by the new filtration system.

It was soon noted that two or more consecutive cleaning cycles caused air pressure to build up in the drain line. At one point, the vice president of the filter manufacturing company was completely soaked with treated but unchlorinated effluent when



This image shows sludge found on the coarse screen of filter just after start-up.

a clamped rubber joint in the drain line blew apart while he was training plant personnel on the filtration system. The situation occurred because the 6-inch drain line from the filters traveled underground about 150 feet to a wet well about 5 feet in diameter. Inside the wet well were two 2-inch residential basement-type sump pumps. Both 2-inch discharge lines were tied together into a single 2-inch line leaving the wet well. This greatly decreased the pump-down capacity of the wet well system. One flush of the filtration system would raise the water level in the wet well above the drain inlet elevation, completely submerging the 6-inch inlet drain pipe. It took the two sump pumps 8½ minutes to remove the water resulting from a single 35-second filter system flush cycle. If a second filter cleaning cycle should occur within 8½ minutes of the last cycle (which often occurs during training sessions) pressure would build up in the drain line and blow apart a joint or create enough back-pressure in the filter cleaning mechanism to prevent effective screen cleaning.



This is an example of what completed installation of two ORIVAL OR-12-PS Automatic Self-Cleaning Filters would look like.

Further investigation showed that two heavy-duty 3-inch sump pumps were specified in the original design but a change was allowed to "save money." The solution for this situation was to provide pressure relief in the drain line so that if the outlet in the wet well was submerged, water could overflow back into the basin from which the effluent came. This is intended to rarely happen or it will be back to pre-improvement conditions with another sludge buildup.

Present Conditions

The way the present system is set up and designed, if temperatures in the methane gas engines rise above a threshold due to insufficient water flow or if reuse pressure drops below a threshold at the belt presses, the effluent supply pumps to the reuse system will shut down and a fault signal will be sent to the operator. He must then manually open a valve to supply the engines and belt presses with potable water. This could and should be automatically done by the control system and may be an added feature in another renovation phase.

All is now working well with phase one of the renovation with reuse running 800 gpm to 1000 gpm. The new filtration system is working appropriately and no nozzles have plugged on the belt presses and no engines have overheated since startup six months ago. Having had no experience with trickling filter effluent, engineers at the filter manufacturer made their design recommendation on activated sludge effluent. This was adequate for phase one flow rates. Additional screen filtration area may be necessary when flows double. This can be accomplished by simply installing a duplicate system in parallel with the existing one. Space is available in the pump room and the existing controller will integrate both dual units into a single operating system.

Management at this facility is definitely proactive in water conservation. They had a premise from the beginning that reuse would be a big part of their future plans. A large reuse system was designed into phase one and phase two of their renovations. A few avoidable, but easily overlooked problems occurred during start-up of phase one. Inexpensive solutions were found and implemented, leaving a reliable, robust water reuse system in full operation.

About The Author

Dr. Marcus Allhands received his B.S. in engineering from Purdue University and his PhD from the University of Florida. He is a registered professional engineer in Illinois and Florida. Allhands spent seven years as water quality manager of an engineering and environmental consulting firm in southwest Florida and then ten years as senior application engineer for an international filtration company. He is now vice president of business development for Orival, Inc., a broad spectrum filtration company. To contact Allhands, e-mail ma@orival.com or call (800) 567-9767.