BIOTRICKLING FILTER TREATS HIGH H_2S IN A COLLECTION SYSTEM IN JACKSONVILLE, FLORIDA

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ABSTRACT

To address high H_2S in a collection system, JEA pilot tested a plastic media biotrickling filter. The pilot unit supplied by Bioway America Inc. reduced H_2S from over 500 ppm to below 1 ppm. In January 2002, JEA installed a permanent system at the Lennox Avenue lift station. The 0.28m^3/s (600 cfm) Bioway system is designed to treat 800 ppm H_2S. The capital cost is $160,000 with annual operating costs of $10,000. A present worth comparison showed biotrickling filters are more cost effective than wet scrubbers, biofilters, and iron salt chemicals. Biotrickling filters are ideally suited for treating very high H_2S concentrations at a low cost.

KEYWORDS

Odor control, collection system, hydrogen sulfide, biotrickling filter.

INTRODUCTION

The JEA (a full service municipal utility located in Jacksonville, Florida) operates several wastewater treatment plants and an extensive collection system for the City of Jacksonville and outlying areas. The terrain in Jacksonville is fairly flat and the temperatures are relatively high throughout the year. The collection system has hundreds of pumping stations, so wastewater is pumped and repumped with a long travel time before reaching the treatment plants. The combination of these factors leads to very high sulfide generation and JEA has been faced with widespread problems of odor and corrosion in the collection system.

To combat sulfide related problems, JEA initiated a comprehensive odor and corrosion control program. The program involves the application of a variety of liquid-phase chemical products, with supplemental vapor-phase treatment devices at many pump stations in sensitive areas. Due to the magnitude of the sulfide problem, the cost of treatment can be enormously expensive. In an effort to minimize costs, JEA has been very active in researching new technologies that offer low-cost treatment.

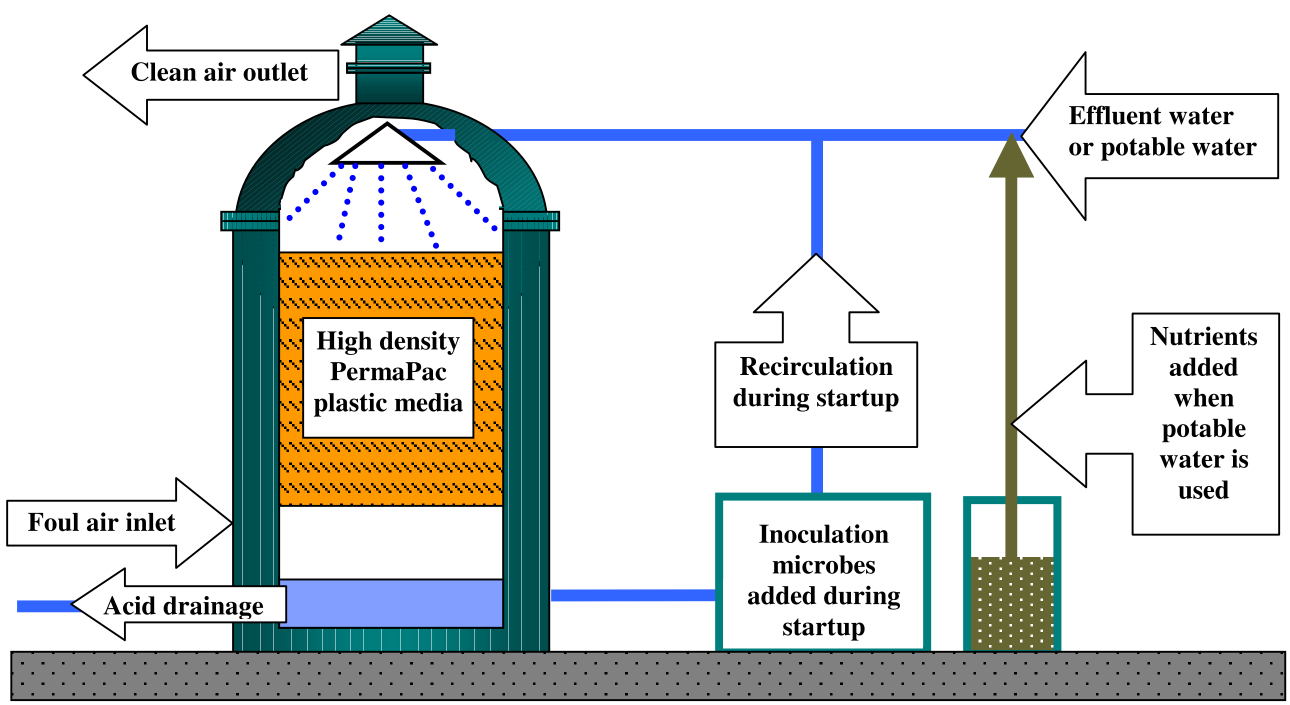
JEA was a leader in applying biofilter technology for vapor-phase treatment at pumping stations. The biofilters provided effective performance at a reasonable cost at many sites. However, at locations with the highest H_2S, the organic biofilter media required too frequent replacement. JEA was interested in alternative biological treatment methods that would cost-effectively treat high H_2S. JEA identified biotrickling filters as a promising candidate for investigation. Biotrickling filters use inert media as a matrix to support biological growth, so the media does not deteriorate as rapidly as organic media biofilters. The biotrickling filter media also supports a high biomass density, so the systems are smaller in size than biofilters. These features make biotrickling filters ideal for high H_2S applications on collection systems where space may be minimal.

PLASTIC MEDIA BIOTRICKLING FILTER

In general, biotrickling filters consist of a containment vessel with some type of inorganic media to support microbial growth. Foul air is introduced at the bottom of the media and with water sprayed over the top of the media. The water flows downward through the media and provides a moist environment that encourages microbial growth. For H_2S treatment the microbes are chiefly *Thiobacillus*, which remove H_2S from the air as it passes through the media. The water also serves to flush the metabolic byproduct of sulfuric acid from the system. At wastewater treatment plants, non-potable water can be used to supply sufficient nutrients for the microbes. For collection system applications, potable water is used and supplemental nutrients are required to support the bacteria.

Various types of inorganic media have been used in experimental biotrickling filters. One vendor provides lava rock media. Lava rock is relatively inexpensive and provides a high surface area, but the weight of the media can be a drawback. JEA elected to evaluate a system supplied by Bioway America Incorporated, which uses plastic media. The high-density PermaPac™ media is composed of acid-resistant polymer material. Because it is light in weight, the media can be stacked in vertical stages to minimize the footprint. The media is resistant to plugging and the vendor guarantees the media for 5 years, but projects it will last up to 10 years. When replacement is needed the top of the unit is removed and the wound cylinder of media is lifted out of the containment vessel in one piece. A new cylinder is inserted into the vessel and the top reattached. A typical system configuration is shown in Figure 1.

Figure 1. Typical Bioway Biotrickling Filter Configuration.



Bioway technology originated in Europe, where it has been applied in numerous wastewater applications. There are now several installations in the United States, with the largest at an industry that treats high sulfide from a groundwater air stripping process. Bioway provides a range of biotrickling filter sizes under the name of Purspring™, with the smallest units referred to as ZeroChem™. The vessels are typically high-density polyethylene, but very large units are constructed of fiberglass reinforced polyester (FRP) with either a polypropylene or a polyvinyl chloride liner. The systems may be configured with a variety of process and control functions that minimize operator attention and reduce the quantity of water used. In Bioway systems, water flow is not continuous, but is applied periodically at the optimum rate needed to promote microbial growth without excessive accumulation of biomass or biological byproducts. The pressure drop across the system is typically less than 0.025m (1 in.) water column. For applications where potable water is used, such as on collection systems, a specially formulated nutrient mixture is provided by Bioway, at a reasonable cost.

PILOT UNIT

JEA commissioned a pilot test of a Bioway biotrickling filter at a duplex pump station on Beach Boulevard in Southeast Jacksonville. The pumping station is located on an extremely sensitive site next to the drive up window of a Rally's Restaurant. The pumping station was identified as a source of odor due to H_2S escaping from the wetwell. The Beach Boulevard pumping station receives flow from an upstream pumping station, so the wetwell fills rapidly and odorous air is forced out around the edges of the hinged aluminum cover.

The pilot unit, supplied by Bioway America Incorporated, was a ZeroChem™ Model 1500 Purspring unit as shown in Figure 2. The Bioway system uses a containment vessel fabricated from high-density polyethylene. The system was operated with potable water, so supplemental nutrients supplied by Bioway were added from a small container as shown in Figure 3. The unit was rated for a 5.7m^3/s (200 cfm) maximum airflow capacity. To ensure that optimum odor control was obtained at this sensitive location, the unit was started at 1.4m^3/s (50 cfm.)

Figure 2. Beach Boulevard Pilot Unit

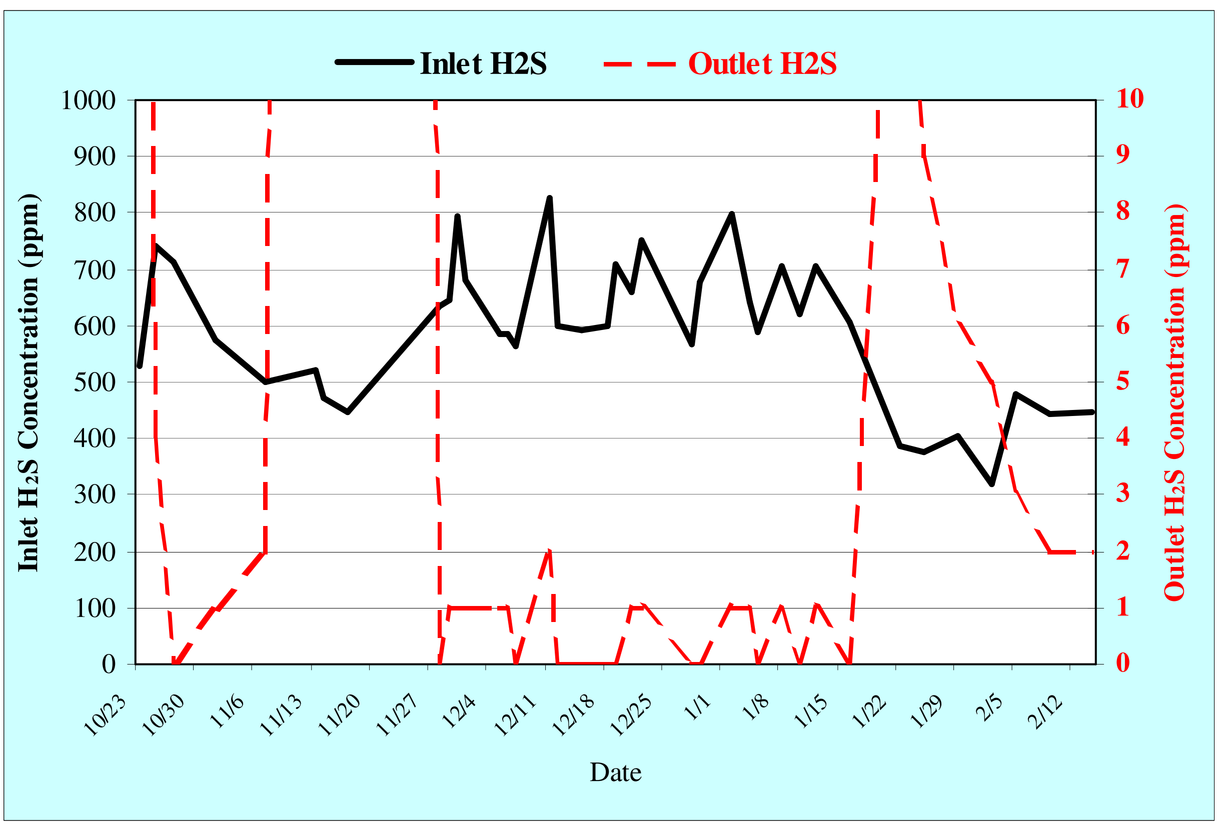
Figure 3. Inoculation Tank and Nutrient Container.

The pilot unit was installed in September 2000, but there were mechanical problems with the recirculation pump, which required the installation of a new pump. Due to the pump malfunction the pilot unit was only operated intermittently for the first month. A new pump was installed in October and the unit was then operated continuously for several months until it was shut down in February 2001. During the startup period, *Thiobacillus* were introduced through the inoculation tank (Figure 3) to quickly establish a microbial population. Due to the initial intermittent operation, the acclimation period was not well defined, but significant H_2S removal commenced within just a few days of startup. Generally, full treatment is expected after two weeks. The pilot unit was operated with a 15 minute wetting cycle and a dosing time of 13 seconds each cycle. The overall water usage was about 950L/d (250 gpd) with these operating settings

JEA collection system staff collected data two or three times per week during the 16 week testing period. Inlet and outlet H_2S were measured using an electronic meter sensitive to 1 ppm. As shown on Figure 4, the inlet H_2S remained high throughout the test period. After the new pump was installed on 11/27, outlet levels were typically at or below 1 ppm through 1/15.

On 11/22 a butterfly valve on the inlet air duct was opened to increase the airflow. Internal turbulence in the inlet duct made air flow measurements inexact, but the adjusted air flow rate was estimated to be about 150 cfm. After adjustment, outlet H_2S increased to 17 ppm, so the valve was readjusted to obtain 100 cfm. At that airflow, the inlet H_2S was reduced to about 450 ppm, but the final H_2S mass loading was increased from previous levels. The outlet H_2S remained about 2 ppm until the test was concluded in February 2001.

Figure 4. Pilot Biotrickling Filter Performance.



FULL-SCALE INSTALLATION

Based on the success of the pilot test unit, JEA decided to install a permanent biotrickling filter at the Lennox Avenue pumping station located in West Jacksonville. The station is located in a residential neighborhood and typically sees 400 to 500 ppm of H2S in the wetwell. An airflow of $0.28 m^3/s$ (600 cfm) is provided to maintain about 6 air changes per hour in the wet well.

The Bioway system consists of dual ZeroChem™ Model 3000 Purspring units connected to the existing wetwell with a 0.3m (12 in.) duct manifold. Each vessel is 3 m (10 ft) in diameter and fabricated from FRP. PermaPac plastic media is employed to provide homogeneous airflow with a minimal pressure drop. Pressure drop across the unit at full airflow is less than 0.25 m (2.0 in.) water column. The plastic media is guaranteed for five years.

A control panel mounted on the vessel houses a Siemans PLC (Programmable Logic Controller) that monitors and controls the operation of the biotrickling filter unit. A SCADA (Supervisory Control and Data Acquisition) option is available to allow remote monitoring or operation. A water control cabinet mounted on the vessel houses solenoid valves, filters, and nutrient addition equipment. The water control cabinet is piped into a pressurized water supply and controlled by the PLC in the control panel.

Figure 5. Full-scale Installation at Lennox Avenue

Figure 6. Full-scale Installation at Lennox Avenue

COST INFORMATION

The capital cost of the full-scale system was $160,000 fully installed with start-up and training costs included. Utility and power requirements for operation are very reasonable. The system operates on a 220V/1PH/60HZ/30amp power supply and requires less than 4,000 kWhr/year. The system requires a 0.03 m (1.25 in.) diameter water line at 6.9 kilopascals (40-75 psi) and uses approximately 45,460 L/d (10,000 gpd) of potable water. Operating at full airflow with 800 ppm H_2S the system will use approximately 1,703 L/y (450gpy) of nutrients at an annual cost of approximately $2,500. Assuming electrical costs of $0.06/kWhr and water costs of $0.53/1,000L ($2/1,000 gal.), the annual operating costs for electric, water, and nutrients is about $10,000 per year. A plastic media replacement cost of $30,000 was assumed at 10 years.

Several other treatment options were examined for comparison with the biotrickling filters. The extremely high H_2S concentration of 800 ppm could not be effectively treated in a wet scrubber, so additional ventilation (8 times the airflow) would have to be provided to reduce the inlet concentration to a more manageable 100 ppm. A package wet scrubber system to treat the higher airflow would cost about $150,000 installed, which is about the same as the biotrickling filter. In comparison, using a wet scrubber with caustic and hypochlorite is projected to cost over $200,000 per year for the chemicals alone.

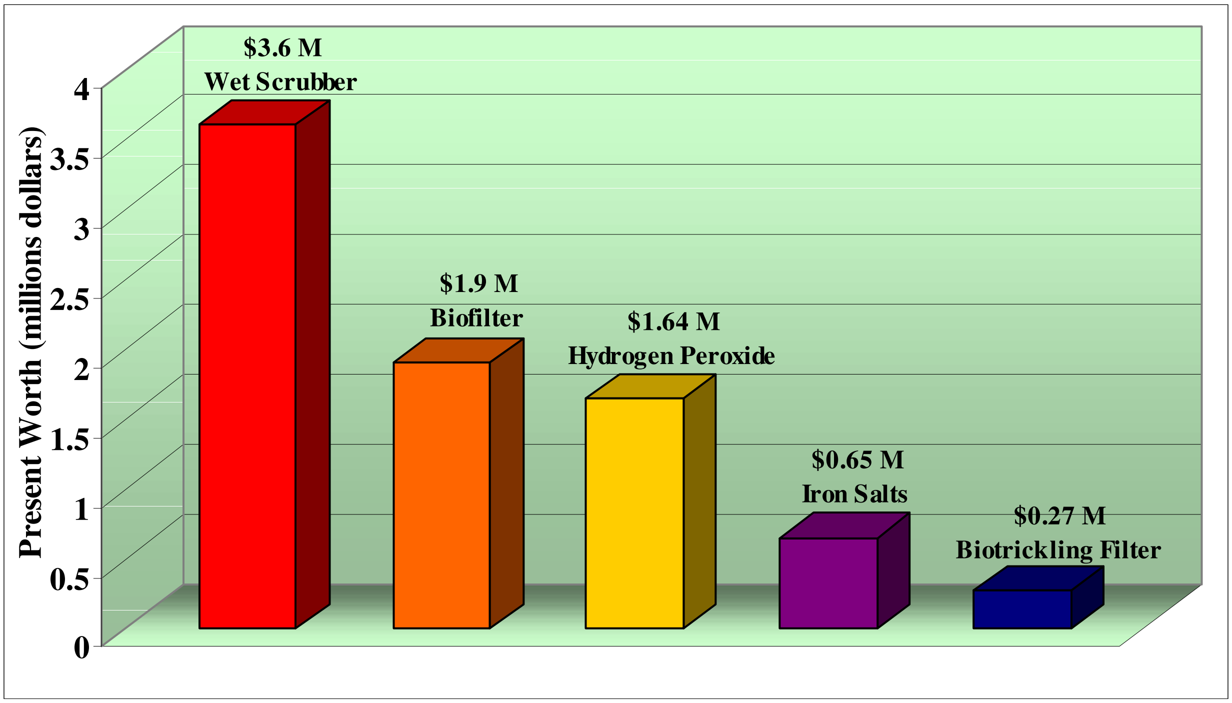
For a conventional biofilter to be effective, the ventilation rate would have to be increased about 16 times to reduce inlet H_2S to 50 ppm. Conventional sizing would result in a biofilter of about $180m^2$(1,920 sf.) A high-quality biofilter in a concrete structure with plenum-type air distribution and a humidification system is estimated to cost $420,000. The annual operating costs are projected to be $275,000, assuming one year of media life.

The biotrickling filter also compares favorably with liquid-phase chemical treatment. Iron salts are often used in collection systems because they are one of the least expensive methods of sulfide control. Assuming treatment of the same mass of sulfide in the liquid-phase as in air-phase 27kg/d (60.4 ppd) would result in annual chemical costs of $22,000. However, this approach would provide incomplete treatment, because only a portion of the sulfide is released to the air-phase. Therefore, additional chemical would be required or some type of vapor-phase device would be needed to treat residual H_2S. For purposes of this analysis, the chemical feed rate is doubled to provide full treatment in the liquid-phase. Based on that assumption, the annual chemical costs would be $44,000. A large injection station would be required with a 20,000L (5,300 gal.) storage tank, pumps, and containment. The capital cost of the injection station is estimated to be $75,000.

Hydrogen peroxide has been applied upstream of the Lennox Avenue lift station and annual costs were reported as $120,000. A permanent injection station for the hydrogen peroxide chemical is estimated to cost $75,000.

Four different treatment options are compared in Figure 7, with present worth calculations based on a 20-year period and a 5 percent rate. Biotrickling filter technology is much more cost effective than wet scrubbers and conventional biofilters. Biotrickling filters are also more cost effective than liquid-phase chemical treatment using iron salts.

Figure 7. Present Worth Comparison of Treatment Options.



CONCLUSIONS

The Bioway pilot unit at JEA's Beach Boulevard lift station performed remarkably well in treating very high H_2S concentrations. The ZeroChem™ Model 1500 was able to reduce H_2S from over 500 ppm to below 1 ppm.

Based on the success of the pilot unit, JEA installed a $0.28 m^3/s$ (600 cfm) unit at the Lennox Avenue lift station in January 2002. The full-scale system consists of dual ZeroChem™ Model 3000 Purspring units connected to a duct manifold. The system was designed to provide effective treatment of up to 800 ppm of H_2S. The Bioway system cost $160,000 to install and annual operating costs were estimated to be $10,000.

A present worth analysis showed that biotrickling filter technology is much more cost effective than wet scrubbers and conventional biofilters. Biotrickling filters even compare favorably with liquid-phase chemical treatment using iron salts. The system is very easy to maintain and fully automated, so minimal operator attention is needed. Biotrickling filters appear to be ideally suited for treating very high H_2S concentrations at a low cost.