HD Q-PAC®

Trickling Biofilters for Hydrogen Sulfide Odor Control

HD Q-PAC delivers 90–95% H_2S removal in less than 10 seconds of contact time — replacing chemical scrubbers at pump stations and large treatment plants.

APPLICATION

Biotrickling filters for H_2S odor control, municipal wastewater

INSTALLATIONS

Saco, Maine pump station; Hyperion Treatment Plant, Los Angeles, CA

H_2S REMOVAL EFFICIENCY

90–95% sustained; <10 seconds contact time (Hyperion)

Simple Biological Process Cuts Chemical Use
by Ming Wu, Chemical Engineer, Lantec Products, Inc.

Introduction

Controlling hydrogen sulfide and other odor emissions is a major issue for most wastewater treatment plants. H_2S odors can be reduced to very low levels by wet scrubbers using caustic and chlorine or sodium hypochlorite. However, the chemical storage, metering, and control equipment all add to the cost of a scrubber. The chemicals are hazardous, and the amounts required to treat H_2S are quite high, so the cost of operating the scrubber can quickly add up.

One way to cut the cost of chemicals is to utilize microorganisms to break down most of the hydrogen sulfide using oxygen from the air. Using microorganisms to remove odor or volatile organic compounds from air streams is not a new idea. Biofiltration has been used, especially outside the United States, for many years.[1,2] For H_2S odor control, the key is to provide an ideal habitat for the growth of sulfide-oxidizing bacteria, to the exclusion of competing microbes which normally predominate in aerobic treatment processes.

Several species of microorganisms can oxidize hydrogen sulfide to form odorless sulfuric acid. A few species of the genus *Thiobacillus* are capable of oxidizing H_2S at low pH. *Thiobacillus thiooxidans*, in particular, thrives at pH <3, and its growth is not inhibited until the pH falls below 1.[3]

PRODUCT

HD Q-PAC

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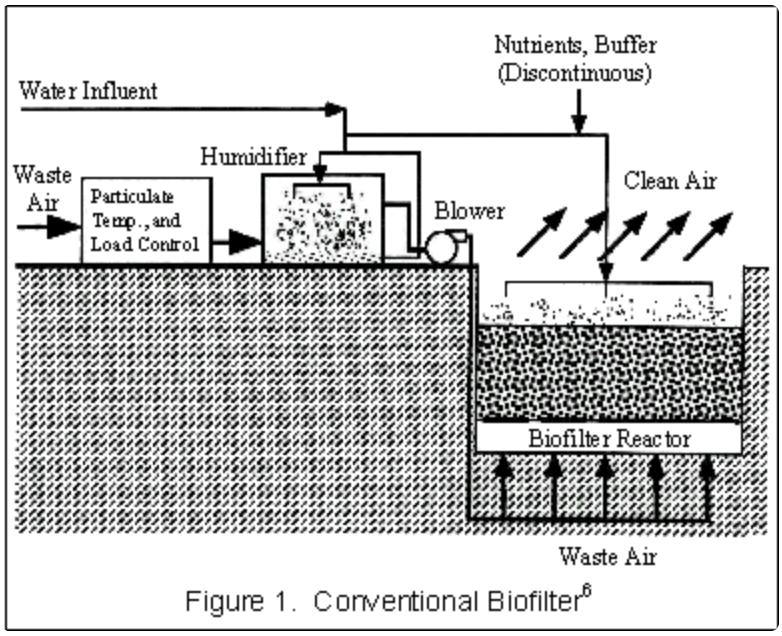
H_2S REMOVAL

90–95%

Sustained removal at both test installations, with less than 10 seconds of air contact time at the Hyperion Treatment Plant in Los Angeles

APPLICATION CONTEXT

- H_2S removal
- Biotrickling filter
- Odor control
- Municipal WWTP
- Pump station



Biofilter diagram

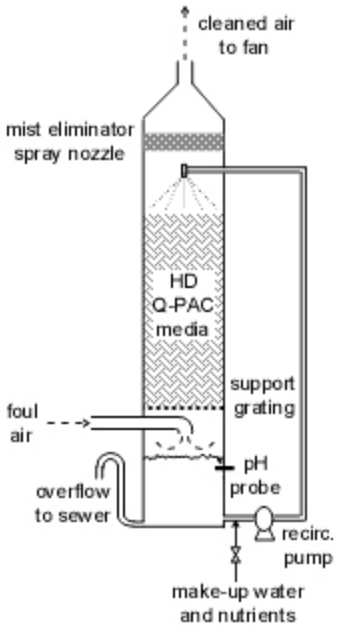
Efficient removal of H_2S requires media with enough surface area to maintain a large population of sulfide-oxidizing microbes. Porous media such as soil, peat, compost and/or wood chips work well in biofilters for removal of organic vapors, although they require careful control of temperature and humidity. If the air is not fully saturated with water vapor, some of the medium may dry out, inactivating the microbes on it. On the other hand, excessive moisture can cause water to accumulate in the media, and eventually wash away nutrients.

The weight of moist media limits the depth that can be used without excessive compression. Worst of all, sulfuric acid formed by biological oxidation of sulfur compounds can degrade such media, causing them to collapse. As a result, conventional biofilters using these media often need a caustic scrubber as a pretreatment stage to humidify the inlet air stream and remove sulfur compounds.

To eliminate the need for pretreatment of the air or for periodic replacement of degraded media, biofilters can be built using acid-resistant inorganic substrates such as porous lava rock. These are referred to as "trickling biofilters" (or "biotrickling filters") because the media is kept wet — regardless of the humidity — by continuous circulation of water.

NOTE

Technical paper by Ming Wu, Chemical Engineer, Lantec Products. Covers design principles and two documented test installations.

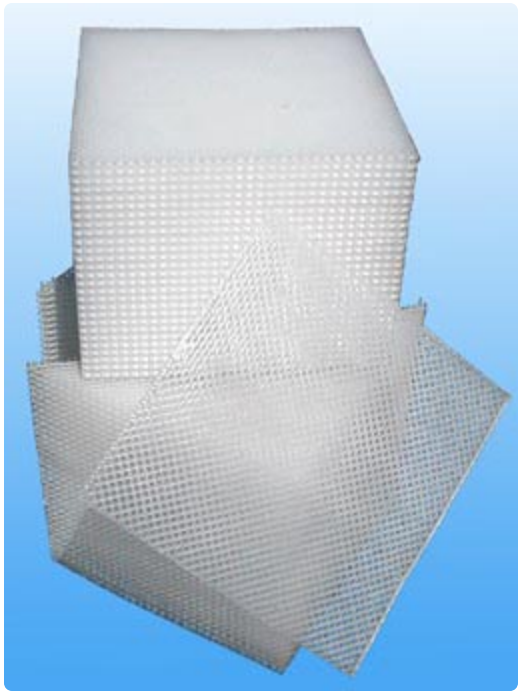


Trickling biofilter installation

However, the weight of rock media makes it difficult to handle, and limits the depth of a filter bed that can be installed without expensive reinforced structures. The fan power needed to force air through a bed of lava rock is also quite high. As a result, trickling biofilters using rock media must be sized for very low gas velocities, resulting in huge footprints.

Nitrifying trickling filters using plastic media have also been used for H_2S odor control,[4] but the limited surface area of conventional trickling-filter media results in relatively low bacterial populations per unit volume. Air residence times on the order of minutes are required for efficient odor removal. The cost of such enormous filters cannot be justified unless they are needed to nitrify wastewater.

In order to overcome the drawbacks of conventional media, Lantec Products has developed a high-density polypropylene media known as HD Q-PAC®.



HD Q-PAC structured media

Physical Characteristics	
Material	Polypropylene
Specific Surface Area	132 ft^2/ft^3
Drip Points	75,000/ft^3
Bulk Density	7.5 lb/ft^3
Void Fraction	87.8%
Smallest Grid Opening	0.16″ × 0.16″
Standard Module Size	12″ × 12″ × 12″

This media is acid-resistant, lightweight, easy to handle, and rigid enough to walk on. It can be stacked to any desired depth. It provides 132 ft^2 of plastic surface per cubic foot, yet it has a high void fraction, so that even when coated with a layer of biofilm it still presents much less resistance to air flow than compost or rock media.

This makes it possible to treat air at higher superficial velocities with reasonable fan power requirements, so trickling biofilters can be made taller rather than wider, saving valuable space in crowded treatment facilities.

◆ TEST INSTALLATIONS

◆ WASTEWATER PUMP STATION ODOR CONTROL

HD Q-PAC® was used in a small trickling biofilter as the only odor removal system at a pump house in Saco, Maine. The pump house is situated in the middle of a residential area, with the closest residence no more than 20 feet away. The treatment plant had gotten odor complaints from residents every summer. A biotrickling filter was installed in May 1999 to evaluate its effectiveness in reducing high H_2S levels during the warm summer months.

Two 55-gallon liquid storage drums with inside diameter of 20 inches were welded together and used as the biofilter vessel. HD Q-PAC® was installed in the tower with the needles oriented vertically. Gaps between the media and the walls of the drums were filled with separated pieces of HD Q-PAC®.

A centrifugal blower rated at 80–100 cfm pushes the air into the biofilter. Contaminated air enters the bottom of the vessel, passes upward through the biofilm-coated media, and exits through the top. H_2S inlet concentrations in the pump house air range from 1 to 90 ppmv.

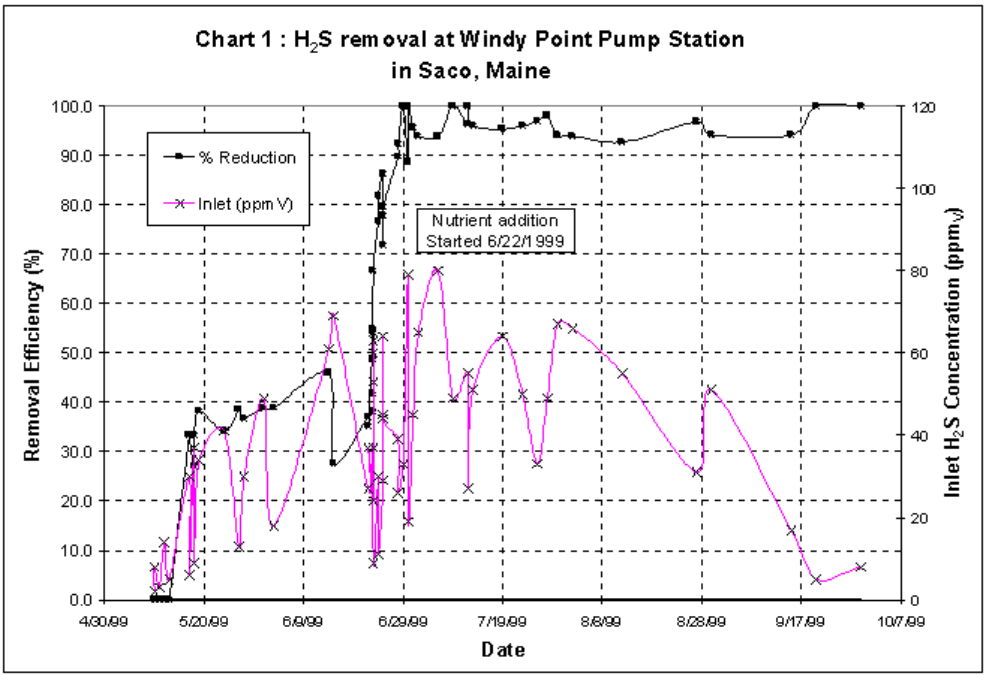
Water is recirculated at 6 gpm. Fresh water with nutrients is added at 1 gpm for 15 min every day. H_2S concentrations are measured using a Scott Alert Meter (Model S108) which is calibrated monthly.

Figure 4. Test Unit at Saco, Maine

Saco pump station biotrickling filter installation

When the biofilter was started up in May 1999, the H_2S removal efficiency increased gradually as biofilm developed on the media, but it remained below

45%. A commercial lawn-fertilizer dispenser was connected to the make-up water line to add ammonium phosphate and urea as micronutrients. After that, the H_2S removal efficiency rose to over 90% within a few days. Since then, the removal has been consistently over 90%, even though the inlet H_2S level varied as much as 400% within the same day.



Saco H_2S removal efficiency over time

Throughout the summer of 1999, with record-breaking high temperatures, the treatment plant did not receive a single complaint about pump station odors.

◆ CENTRAL WASTEWATER TREATMENT PLANT

HD Q-PAC® was also tested in a trickling biofilter to remove hydrogen sulfide from exhaust air at the Hyperion Treatment Plant in Los Angeles, California.

This test filter has an inside diameter of 4.5 ft and is packed with 7 ft of media. HD Q-PAC® was installed in the tower with its needles oriented horizontally. Each rectangular module of media was stacked tightly against the others, leaving no gaps between them. Gaps between the HD Q-PAC® and the walls of the circular tower were filled in with small pieces of porous rock.

A blower sends untreated air into the bottom of the trickling biofilter. The air flows upward through the biofilm-coated media, while the water trickles down over it. The treated air exits the top of the unit.

The filter was initially used to treat 700 cfm of air containing 2–20 ppmv of H_2S. Water was recirculated over the media at a rate of 10 gpm.

The unit was started up by filling the 300-gal sump with secondary effluent from the treatment plant, then running the fan and recirculation pump

continuously until bacteria began to colonize the media, and the pH of the water decreased to less than 2.0. After that, a portion of the acidic solution was made to overflow every 4 hours by adding secondary effluent at 3 gpm for 20 minutes.

In addition to controlling the pH, the 360 gallons of make-up water added each day provided micronutrients needed for growth of the biofilm. (*Thiobacillus thiooxidans* is autotrophic; it uses atmospheric CO_2 as its carbon source.)

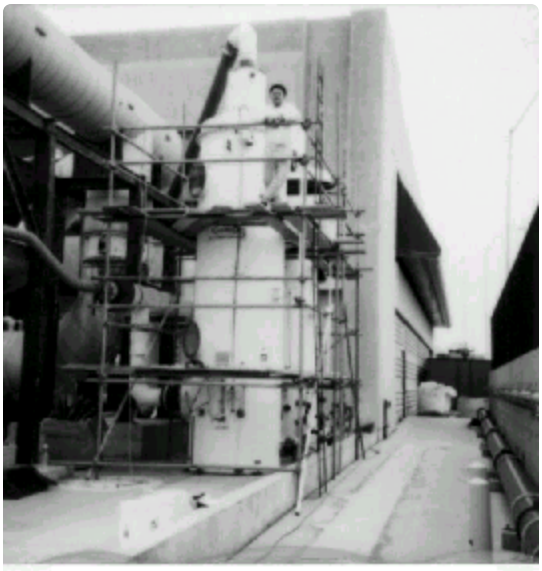


Figure 5. Hyperion Plant Test Unit

Hyperion Treatment Plant biotrickling filter installation

The H_2S concentrations in the inlet and outlet air streams were measured daily using an Interscan Voltammetric Sensor.

The removal efficiency of H_2S increased steadily for the first few days of operation, reaching 90% within 10 days.

Ever since then, the removal efficiency has remained between 90% and 95%, with higher efficiencies recorded occasionally. Since the initial start-up period, the H_2S removal efficiency has never fallen below 90%.[5] This is in a small trickling biofilter with less than 10 seconds of residence time.

Parametric studies aimed at optimizing the operating conditions are now under way, and will be reported in a future paper. However, the consistent performance of this test unit over a period of months has demonstrated conclusively that the proper environment for *Thiobacillus* growth can be maintained using HD Q-PAC® and extremely simple equipment.

◆ POSSIBLE APPLICATIONS

The biofilter at Hyperion Treatment Plant using HD Q-PAC® will be scaled up to pretreat large volumes of exhaust air which is now being processed by conventional wet scrubbers.

Figure 6. The author installing HD Q-PAC®

Ming Wu installing HD Q-PAC media

Wastewater treatment plants in urban areas are among the world's largest consumers of sodium hypochlorite. By removing 90% or more of the H_2S using atmospheric oxygen, the operating cost of chemical oxidants for the scrubbers can be cut by hundreds of thousands of dollars per year. The existing scrubbers will continue to function as a "polishing" stage, and as a back-up in case of any problems with the trickling biofilters.

These biofilters are particularly well suited for odor control at isolated pumping stations and other facilities where there is no-one to operate a conventional wet scrubber, even if a water system could afford the equipment and the chemicals needed to scrub small air streams at many scattered locations. These filters are simple enough to run automatically without operator attention, and with no need to store hazardous chemicals at multiple unguarded sites.

In many developing countries, the capital and operating costs of wet scrubbers are more than treatment plant budgets can bear. The simplicity of trickling biofilters, and their ability to operate without expensive chemicals, provide a badly needed alternative in this situation.

Trickling biofilters may also find use as simple pretreatment stages for conventional biofilters for VOC removal. They can humidify air and greatly reduce its sulfur content, extending the useful life of water-absorbent biofilter media while eliminating the need for treatment chemicals.

References

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