BIOGAS UPGRADING - DESULFURIZATION
Part 4: Biotrickling filters for H_2S - Process control options

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Controls and innovative processes to improve the performance of biotrickling filter (BTF) and the oxidation of H_2S to sulfate by sulfur oxidizing bacteria (SOB) are summarized below.

PROCESS CONTROL

Biogas loading

In NYS typical biogas flow rates are 100-400 cfm. While BTF systems have been designed for H_2S concentrations up to 12,000 ppm, in NYS inlets are generally less than 7,500 ppm. Based on biofilter volume, in NYS BTF loading rates are 0.18-0.20 lb. $H_2S/ft^3/h$, higher than those typically reported[1]. Empty bed residence times in NYS are ~7-8 min., within the acceptable range of 2-16 min.[2], but slower than many high performing systems with < 1 min. residence times[3]. *Thus, there may be opportunity in NYS to reduce reactor size or treat more gas with currently sized systems if BTFs are operated at high efficiencies.*

Water flow rate (trickling density)

The water flow rate is set for a particular liquid-to-gas ratio, with media desiccation delimiting the minimum and tower flooding the maximum. Typically the ratio is set at 1.1-1.7× the minimum (~20 gal./h/ft^2 cross sectional area), well below a trickling density of $\geq$ 120 gal./h/ft^2 where biofilms can dislodge. While the water flow rate is typically fixed, increasing the trickling density is a potential strategy to improve the H_2S removal of high inlet loading events, and in counter-current BTFs can also increase dissolved oxygen concentrations. It is important to note that higher trickling densities also increase BTF media liquid film thickness, increasing mass transfer resistance (reducing the elimination capacity of less-soluble emissions) as well as the pressure drop[4]. *As these tradeoffs suggest, there is the potential to optimize trickling density to improving oxygen delivery to SOB for increased sulfate production and reduced sulfur buildup[5].*

Water discharge

Water must be discharged at a rate that minimizes water usage but optimizes removal of accumulated breakdown products (i.e. sulfate) which acidifies the system. In NYS, desulfurization BTFs which are operated under acidic conditions, typically discharge at pH 1.3 or an electrical conductance of 14,000-21,000 µs/cm. *Calibration of pH and conductance meters is crucial to ensure optimal water usage.*

Rapid drop in pH can lead to a preferential generation of sulfur while high pH can result in the formation of products inhibitory to SOB activity[5]. *Buffering compounds added to control pH can extend the useful life of trickling water[1], but renewal of nutrients and flushing of salts is unavoidable.*

Oxygen delivery

The O_2/H_2S ratio is critical to biofilter operation (see Part 2 of this Fact Sheet Series). *To optimize desulfurization, while minimizing S^0 accumulation and biomethane dilution, the air delivery rate could be adjusted to match H_2S loading.* A blower is typically used to mix air with biogas for oxygen delivery. As H_2S is ~80× more soluble in water than oxygen, significant air is needed for desulfurization. *To avoid biogas dilution with air and formation of sulfur due to an oxygen limited environment, trickling water can be aerated to more effectively deliver dissolved oxygen to the* *biofilm.* A venture aeration system has shown significant promise[6], and may be worth consideration by BTF operators.

Inoculation & Nutrients

Most NYS farm biogas BTF operators inoculate systems at start-up. Few inoculate regularly during operation. Re- inoculations are likely unnecessary unless the BTF microbial community fails or is removed by cleaning. To reduce lag following BTF cleaning, some farms retain trickling water to re-inoculate fresh media. *More work is needed to optimize inoculations, but retaining trickling water for re-inoculation after cleaning could be advantageous.*

Addition of nutrients is essential to BTF function, but there is opportunity to improve and cater nutrients to particular systems to optimize desulfurization. Glucose for example, can be added to stimulate H_2S oxidation, but in excess can lead to excessive microbial growth and pressure drop [7]. Ultimately, nutrient optimization research is needed.

Cleaning

Regular flushes (~15 min. every 2 hr.) with jetted water are used to prevent media caking. Semi-annual (2× yr.) backwashing of the media with agitation have been used by BTF operators to more thoroughly clean deposits off media. Additionally, removal of media for manual cleaning is encouraged bi-annually to ensure proper system function.

Capitalizing on the ability of SOBs to completely oxidize H_2S when oxygen is not limited, aeration and trickling can be run in the absence of biogas to stimulate SOB oxidation of built-up sulfur to sulfate, effectively cleaning the media[5]. *This strategy may be useful during biogas engine gen-set servicing and other downtimes to improve the efficacy of backwashing and reduce the frequency of manual cleaning.*

FACT SHEET SERIES

Biogas upgrading - Desulfurization

Part 1: What are the available technologies for desulfurization of biogas?
Part 2: Microbial underpinnings of H_2S biological filtration.
Part 3: Biotrickling filters for H_2S - Overview of configuration and design.
Part 4: Biotrickling filters for H_2S - Process control options.

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