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## Abstract
Hydrogen sulphide is one of the most toxic and corrosive compound present in swine-derived biogas streams. In this study, a field scale biotrickling filter for the removal of hydrogen sulfide was investigated. A Biofilter packed with supporting biofilm materials was fed continuously with a proprietary nutrient solution and operated for over 73 days. The system has been operating with a $H_2S$ inlet concentrations ranging from 1,000 to 3,000 ppm. Significant removal efficiencies >95% was demonstrated. pH of the stock feeding solution decreased from 6.2 to as low as 3.5 within couple days. The resulting drop in pH provided circumstantial evidence to support biological $H_2S$ oxidation to sulphuric acid by sulfide-oxidizers. Sulfur precipitation was also observed to occur. The results suggested that $H_2S$ removal from biogas stream can be efficiently achieved using portable, low cost and maintenance free biotrickling filters.

## Keywords
Biogas; Biotrickling filter; Hydrogen sulfide; Desulfurization.

## INTRODUCTION
The use of biogas as a potential source of renewable biofuel has been drawing attention in many countries. However, biogas often contains high concentrations (0.1–2%) of toxic hydrogen sulphide ($H_2S$) (Anet ,2013) that must be removed from gas stream to prevent overall infrastructure corrosion and failures. Biogas purification methods can be classified into two main categories which involve physical-chemical or biological processes (Abatzoglou, 2009). Biological methods such as the use of biotrickling filters (BTFs) are technically effective and economically feasible compared to other traditional physical-chemical processes (Omri, 2013). Moreover, biological filtering processes are less prone to contribute to environment pollution (Elias et al., 2002; Kim et al., 2002; Oyarzún et al., 2003; Sercu et al., 2005). In these biological systems, a source of sulfide-rich gas stream typically passes through a packed-bed closed reactor containing suspended or fixed microorganisms that are able to oxidize $H_2S$ into harmless byproducts (Ma et al., 2006). When degrading inorganic compounds such as hydrogen sulphide, autotrophic bacteria utilize carbon dioxide as a carbon source resulting in the production of new biomass and sulphate or elemental sulphur (Barona et al., 2004).

Although the use of biofilters have been extensively reported, its development and implementation still holds challenges when it comes to field scale functionality, maintenance of removal efficiencies over time and operating costs. For instance, process controls techniques such as the introduction of selected microorganisms and the metabolic maintenance of system´s microbiology, oxygen injection and nutrient formulations are major factors affecting the economic feasibility of the process as well as labor requirements. For that matter, the objective of this study was to evaluate the removal efficiency of a low cost and maintenance free field scale biotrickling filter to biological remove sulphide ($H_2S$) from biogas produced in anaerobic digester treating swine wastewater.

## MATERIAL AND METHODS

### Biotricking filter setup and operation

A 1.5m high 0.2 m diameter PVC was used to build the biotrickling filter (BTF). The reactor was packed with supporting materials for biofilm fixation and fed with a proprietary nutrient solution blend (patent pending). The gas stream passing through the system was adjusted initially to 400 mL/min using a rotameter (Omega) which resulted in a hydraulic retention time of 97 min. The reactor was continuously fed biogas from an upflow anaerobic sludge blanket reactor (UASB) located at EMBRAPA (Concórdia, SC, Brazil) wastewater treatment facility. Fig. 1 provides a schematic of the setup. Liquid samples were collected over time for analyses of pH, dissolved oxygen and ammonia-N by potentiometric methods. Nitrite ($NO_2^{-}$-N), and nitrate ($NO_3^{-}$-N) concentrations were determined using a flow injection system (FIAlab-2500). Dissolved sulfide concentrations were estimated by colorimetric assays (APHA, 2012). Gaseous samples were monitored over time in the influent and effluent of the biotrickling filter using a gas analyser (Biogas 5000-Geotech).

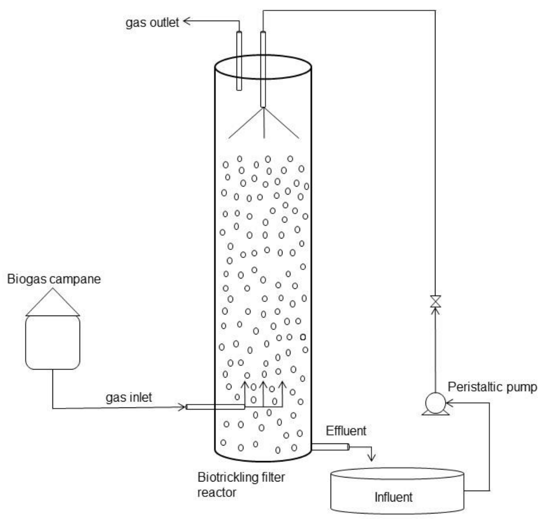


**Figure 1.** Schematic of a counter-current biotrickling filter.

## RESULTS AND DISCUSSION

The biotrickling filter was monitored for over 73 days. Figure 2 shows the concentration profiles of $H_2S$, $CO_2$ and $CH_4$ in the reactor´s influent and effluent gas lines over time. $H_2S$ removal efficiency >92 % was rapidly observed since the begining of the experiment, suggesting very short biological acclimation time. $H_2S$ removal efficiency as high as 98% was observed intermittently. Variations in removal efficiency are expected due to inherent fluctuations in $H_2S$ influent concentrations from 1,100 to 3,000 ppmV. Whereas most biofilters use aerobic culturing media or injection of oxygen to promote $H_2S$ aerobic oxidation, in this study, significant removal efficiencies were achieved under anaerobic conditions. Without replacing the culturing media, sulfuric acid concentrations increased in the media and decreased pH to as low as 3.5 (Figure 3). At this low pH, culturing media was replaced since it can affect $H_2S$ removal efficiency (Jaber et al, 2014). Figure 4 shows that when the anoxic conditions were established (DO <0.1 $mg.L^{-1}$) removal efficiency did not decrease. The concentration of $CO_2$ in the gas stream also decreased after the biofilter. Whereas $CO_2$ was being used as carbon source to $H_2S$-oxidizers or being removed by dissolution only remains unknown and requires further investigation.

Accumulation of a yellowish sludge deposited at the bottom of the culturing media reservoir indicated deposition of elementary sulfur (Figure 5). This was not surprising since trace amounts of oxygen in the nutrient stock solution could promote biological $H_2S$ oxidation to sulfur (Prescott et al., 2003). Moreover, as previously reported, by Rattanapan (2011), in oxygen-limited environments, oxidation may proceed only to elemental sulphur.

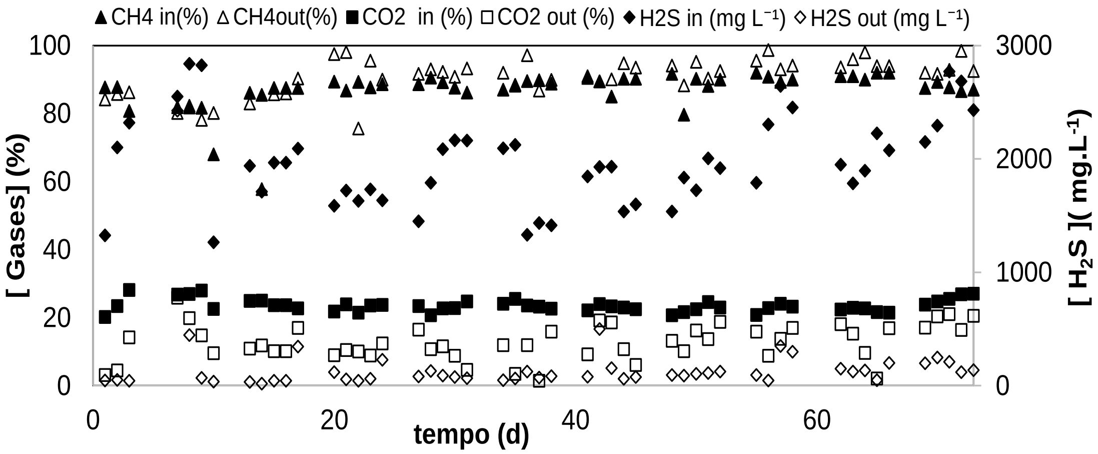


**Fig 2.** Biotrickling filter evolution over the course of 73 days of monitoring. Inlet and outlet gases concentrations and removal efficiency of hydrogen sulfide

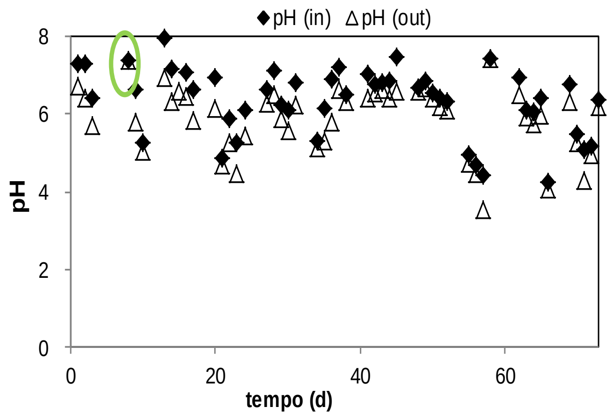


**Fig 3.** Changes in pH over time at the inlet and outlet of the reactor over time

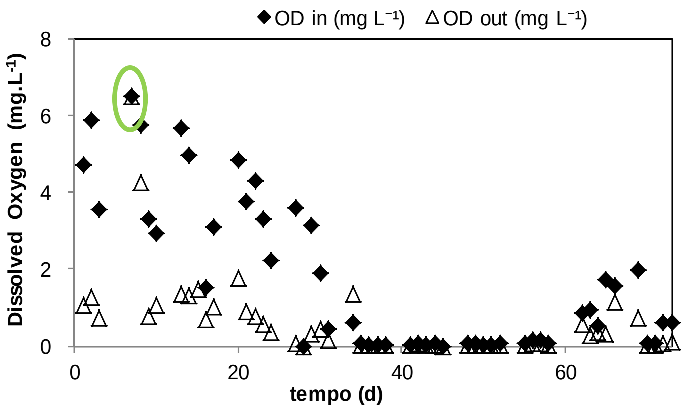


**Fig 4**. Dissolved oxygen concentration over time at the inlet and outlet of the reactor.

**Fig 5**. After a couple days, a clarified nutrient solution showed the presence of a yellowish sludge indicating deposition of elementar sulphur ($S_0$) in the stock feeding solution reservoir.

## CONCLUSIONS

This study demonstrates the efficiency of a field scale anaerobic biofilter to remove $H_2S$ from biogas stream. The time required for reactor´s acclimation was negligible. Removal efficiencies as high as 98% were achieved. The system seemed capable of recover elementary sulfur during the biological process. Whether this sulfur can be employed as a valuable fertilizer remains unknown and should be studied further.

## ACKNOWLEDGEMENTS

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