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Evaluation of Biogas Biodesulfurization Using Different Packing Materials

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Abstract: The packing material selection for a bioreactor is an important factor to consider, since the characteristics of this material can directly affect the performance of the bioprocess, as well as the investment costs. Different types of low cost packing materials were studied in columns to reduce the initial and operational costs of biogas biodesulfurization. The most prominent (PVC pieces from construction pipes) was applied in a bench-scale biotrickling filter to remove the H_2S of the biogas from a real sewage treatment plant in Brazil, responsible for 90 thousand inhabitants. At the optimal experimental condition, the reactor presented a Removal Efficiency (RE) of up to 95.72% and Elimination Capacity (EC) of 98 $gS{\cdot}m^{-3}{\cdot}h^{-1}$, similar to open pore polyurethane foam, the traditional material widely used for H_2S removal. These results demonstrated the high potential of application of this packing material in a full scale considering the robustness of the system filled with this support, even when submitted to high sulfide concentration, fluctuations in H_2S content in biogas, and temperature variations.

Keywords: packing material; PVC; open-pore polyurethane foam; PET; Teflon; biotrickling filter; hydrogen sulfide elimination; H_2S

1. Introduction

Biogas, generated in wastewater treatment plants, typically composed of methane (CH_4), carbon dioxide (CO_2), and traces of hydrogen sulfide (H_2S), is often burned in flares to minimize its contribution to the greenhouse effect [1]. However, in the current global scenario, its commercial value has been increasing due to its high-energy content. The use of this versatile and renewable energy source can bring high cost savings [2]. A limiting factor for the use of this biogas is the wide variety of contaminants present in its composition, such as sulfur compounds, siloxanes, hydrocarbons, and halogenated organic compounds, of which H_2S is the most harmful for energy conversion equipment, due to its corrosive character.

Bed clogging is one of the biggest problems of biotrickling filters, being caused by solid accumulation (biomass and elemental sulfur), and limiting high treatment rates [3]. Problems with elemental sulfur accumulation have been observed since one of the first works described for H_2S removal from biogas in a biotrickling filter (under aerobic conditions) [4]. Due to this, a wide variety of packing materials has been studied in order to overcome this problem and improve the biofilter performance; among them are open pore polyurethane foam (OPUF), polyester fibers, pall rings, porous lava rock, activated carbon, glass beads, and perlite. On the other hand, the choice of the packing material is also related to the economic viability of the biofilters, since materials with a low purchase cost and low pressure drop (low resistance to gas flow) can significantly decrease the operating cost. In this point of view, the use of low-cost packing materials such as expanded schist (inorganic) and cellular concrete waste was also studied for biogas biodesulfurization [5].

In biotrickling filters, the gas flow passes through an inert packing material to which the microbial community attaches. Considering that different types of forces (electrostatic and hydrophobic interactions, and covalent and partial covalent bond formation, among others), are involved in the microbial attachment to a packing material [6], the material surface properties can implicate in different biofilm formation, resulting in different performance of bioreactors. Therefore, the characteristics of the packing material play an important role in the sulfide elimination from biogas (Table 1) and some factors should be observed to choose the best support material:

(a) High surface area for biofilm growth and mass transfer;
(b) Hydrophobicity;
(c) Mechanical, chemical, and biological resistance;
(d) Low pressure drop, especially considering pilot operation

Table 1. Packing material characteristics.

Packing Material	Specific Surface Area ($m^2 \cdot m^{-3}$)	Density ($kg \cdot m^{-3}$)	Porosity (%)	Reference
Lava rocks	200 ± 50	-	-	[7]
Plastic fibers	650 ± 50	-	-	[7]
Open pore polyurethane foam	600	35	97	[8]
Polypropylene pall rings	320	110	88	[9]
Metallic Pall rings	515	520	-	[10]
Honeycomb	620	-	88	[11]

Open pore polyurethane foam is a commercial packing material developed especially for biotrickling filtration [12]. Although conventional polyurethane foam is hydrophobic, its properties are extensive and can vary due to the starting molecules and reaction conditions of manufacture [13]. According to Lisiecki et al. [14], open pore polyurethane foam (TM25450) is formed by thermal compression of conventional foam which leads the cell walls to collapse. The advantages of OPUF are its high porosity, suitable pore size, low density, high specific surface area and reasonable resistance to compaction [8].

The first works carried out using OPUF were developed to treat odorous air. Gabriel et al. [8] proposed the use of OPUF foam as packing support based on the successful results obtained by Loy et al. [15].

Under anoxic conditions, Fernández et al. [16] developed one of the first works using OPUF cubes (8 cm^3), obtaining a critical EC of 60 $gS\text{-}H_2S \cdot m^{-3} \cdot h^{-1}$ (empty bed residence time (EBRT) of 240 s). Using the same system (packed bed volume of 2.375 L), Montebello et al. [17] showed the simultaneous removal of H_2S and methylmercaptan (CH_3SH) from biogas to be feasible, however, loads higher than 100 $gS\text{-}H_2S \cdot m^{-3} \cdot h^{-1}$ negatively affected the CH_3SH removal due to competition. The maximum elimination capacity achieved was 140 $gS\text{-}H_2S \cdot m^{-3} \cdot h^{-1}$.

Fernández et al. [18] operated a laboratory scale biotrickling filter for 620 days and demonstrated that the optimal conditions were: Sulfate concentration below 33 $g \cdot L^{-1}$, pH between 7.3–7.5, temperature of 30 °C, and trickling liquid velocity (TLV) higher than 4.6 $m \cdot h^{-1}$. Higher critical elimination capacity was observed under a nitrate programmed feeding regime (130 $gS \cdot m^{-3} \cdot h^{-1}$, RE 99%, EBRT 2.4 min) when compared to a manual feeding regime (99.8 $gS \cdot m^{-3} \cdot h^{-1}$, RE < 99%, EBRT 3.4 min). The maximum elimination capacity was 170 $gS \cdot m^{-3} \cdot h^{-1}$ for both regimes. Comparatively, Guerrero and Bevilaqua [19] observed optimum temperatures between 31–42 °C and EBRTs from 2.9 to 6.2 min for H_2S removal from the biogas generated from an up flow anaerobic sludge blanket reactor (UASB) at the wastewater treatment plant of a brewery.

On the other hand, for a pilot-scale biotrickling filter, Almenglo et al. [20] observed the best performance under counter-current flow, achieving a maximum elimination capacity of 140 gS·m^{-3}·h^{-1}. Almenglo et al. [21] recommended some important guidelines to startup the biotrickling filter in order to avoid sulfide accumulation in the early stages of reactor operation: An inlet load (IL) around 100 gS·m^{-3}·h^{-1} and pH of 6.8 to decrease the solubility of the sulfide.

Pall rings are widely used in chemical scrubbers due to their high free volume, low-pressure drop values, and uniform gas-liquid contact. Due to these characteristics, it is possible to transform conventional scrubbers into biotrickling filters just carrying out microorganism's immobilization. Polypropylene Pall rings have low specific surface area when compared with open pore polyurethane foam and other packing materials (Table 1), however, according to Fernández et al. (2013), this characteristic can minimize the pressure loss due to biomass and sulfur accumulation. Pall rings are a hydrophobic packing material [22].

The conversion from scrubber to biotrickling filter was first applied to air pollution control; however, in recent decades, the use of Pall rings as packing material has extended to biotrickling filters for H_2S removal from biogas. Under aerobic conditions, Tomas et al. [23] achieved a maximum elimination capacity of 170 gS-H_2S·m^{-3}·h^{-1} in a full-scale biotrickling filter (gas contact time of 180 s, pH 2.6–2.7). The biofilter was composed of four modular sections with an inner diameter of 1.4 m and height of 8 m. Montebello et al. [10] operated a biotrickling filter packed with metallic Pall rings for approximately two years, treating synthetic biogas with a 2000 ppmv H_2S concentration. Under neutral pH, the maximum and critical EC were approximately 100 gS·m^{-3}·h^{-1} and under oxygen appropriate load it was possible to minimize the elemental sulfur formation. This behavior was not observed under acidic pH. In addition, under acidic pH, deterioration of the packing material was observed. Under anoxic conditions, Fernández et al. [9] achieved 99% H_2S removal efficiency under inlet loads lower than 120 gS·m^{-3}·h^{-1} in an anoxic biotrickling filter (working volume of 2.4 L), using controlled nitrate feeding by oxidize-reduction potential (ORP).

López et al [24] studied the main parameters involved in the oxygen mass transfer efficiency in an aerobic biotrickling filter, in order to reduce the elemental sulfur production under high H_2S loads. The trickling liquid velocity and co-current flow showed to be better to manipulate when compared to air supply flow rate and counter current flow mode, increasing 10% the EC and 9% the selectivity to sulfate as product of the H_2S oxidation under 283.8 gS-H_2S·m^{-3}·h^{-1}. López et al [25] also used the feedforward control through the trickling liquid velocity and observed a reduction of 68.4% of the maximum outlet H_2S concentration and the sulfate selectivity improved 100.6 ± 5.0%. A biotrickling filter packed with Pall rings was used by López et al. [26] to develop, calibrate, and validate a dynamic model to describe the main processes involved in the H_2S removal from biogas (high loads). The model was capable to predict the biotrickling operation, besides being able to describe the main products of the H_2S oxidation.

Other packing materials have been used under aerobic conditions. Montebello et al. [27] evaluated the performance of a biotrickling filter packed with HD-QPAC (volume of 2.15 L) under IL from 51 to 215 gH_2S·m^{-3}·h^{-1} and observed a maximum elimination capacity of 201 gH_2S·m^{-3}·h^{-1} and maximum RE of 100% (EBRT of 180 s). The decrease in the O_2/H_2S ratio resulted in an increase in S^0 production. Fortuny et al. [28] also used HD-QPAC as packing material in a biotrickling filter (total volume of 2 L). An important effect of the EBRT on the RE was observed when the EBRT decreased from 120 s (97.7 ± 0.3%) to 30 s (39.7 ± 0.9%).

Qiu and Deshusses [11] showed a promising alternative to the use of conventional packing material. The authors evaluated the use of 3D-printed honeycomb monolith, composed of 19 hexagonal channels, in order to reduce bed-clogging problems under high H_2S concentration through the presence of connected and straight channels. The elimination capacity exceeded 120 gS·m^{-3}·h^{-1} at an H_2S/O_2 ratio of 1:2. Elemental sulfur was obtained as the predominant end-product, with accumulation in the bed. However, the bed pigging was shown to be efficient for removing elemental sulfur and excess biomass.

Vikromvarasiri et al. [29] studied a biotrickling filter filled with random packing media (working volume of 1 L) and inoculated with *Halothiobacillus neapolitanus* NTV01 (HTN), isolated from activated sludge. Air was supplied as the final electron acceptor. Different operational parameters were compared under short-term and long-term operation. The relationship between IL and EC was higher in the long-term (0.931) when compared to short-time operation (0.915). The maximum elimination capacity obtained was 78.57 $gH_2S \cdot m^{-3} \cdot h^{-1}$ for an IL of 85.25 $gH_2S \cdot m^{-3} \cdot h^{-1}$.

Recently, Jaber et al. [5] proposed the use of a biofilter packed with expanded schist (inorganic) and cellular concrete waste (recycled mineral waste), low cost materials, to treat H_2S from biogas. Both materials demonstrated low pressure drops, which is very desirable. The maximum elimination capacity obtained for the expanded schist was 30.3 $g \cdot m^{-3} \cdot h^{-1}$ and 25.2 $g \cdot m^{-3} \cdot h^{-1}$ for the cellular concrete waste.

In recent decades, some studies have been carried out to demonstrate the viability of retrofitting existing chemical scrubbers to full-scale biotrickling filters for H_2S control. Gabriel et al. [8] and Gabriel and Deshusses [30] demonstrated that biotrickling filters can replace chemical scrubbers successfully, being safe and economical. Nevertheless, Gabriel et al. [8] estimated that the expenditure on packing material is approximately \$500–1000/m^3, representing a large percentage of the costs. Tomas et al. [23] compared the investment costs involved in H_2S removal using chemical and biological treatment and showed an investment of \$52,000 for the biological treatment (including reactor, blower, pump, and packing material) compared to \$8700 for the chemical oxidation treatment. This evidence reinforces the need to search for new packing materials aimed at reducing investment costs. Recently, Cano et al. [31] compared the life cycle of different technologies such as aerobic biotrickling filtration, anoxic biotrickling filtration, caustic chemical scrubbing and absorption on impregnated activated carbon, and it was included the analyses of the capital expenditures. The results showed that a biotrickling filter made with fiberglass reinforced plastic (total volume 10 m^3, packing bed volume 5.3 m^3, diameter 0.9 m) can cost €17,090, compared to €5224 of a scrubber made of the same material (total volume 1.7 m^3, packing bed volume 1.1 m^3, diameter 0.7 m).

In this work, the immobilization of biomass on different low-cost packing materials, such as, PET, PVC and Teflon, was studied and the material that showed the best thiosulfate removal efficiency (PVC) was evaluated in a biotrickling filter for H_2S removal from real biogas. The effects of the EBRT, temperature and IL were studied.

2. Materials and Methods

2.1. Inoculum and Packing Material

The anaerobic sludge used in this work was obtained from the Matão Sewage Treatment Plant (São Paulo, Brazil).

Strips of Polyvinyl Chloride (PVC) obtained from Tigre® building pipes (Ref. 10121744 from manufacturer, Tigre, Brazil), Polyethylene Terephtalate (PET) from common soda bottle, Polytetrafluoroethylene (Teflon®, Teflon, Brazil) dowels cut into strips and OPUF (Filtren TM25450, Recticel Iberica, Spain) were used in order to evaluate the potential of low-cost carrier materials (Figure 1) for the immobilization of sulfur-oxidizing microorganism. The surface area of each packing material was analyzed based on the Brunauer, Emmett and Teller theory by the Center for Materials Characterization and Development (Ufscar, São Carlos, Brazil) (Table 2).

Table 2. Packing material characteristics [32].

Material	Surface Area ($m^2 \cdot g^{-1}$)
PVC	0.432
PET	0.443
Teflon	0.909
OPUF	6.694

(a) (b) (c) (d)

Figure 1. Packing materials: (**a**) PVC; (**b**) PET; (**c**) Teflon®; (**d**) OPUF.

2.2. Experimental Set-Up of Laboratory-Columns Packed with Different Low Cost Materials

Four glass columns (active height of 280 mm, inner diameter of 60 mm, and working volume of 792 mL) packed with PVC, PET, Teflon and OPUF (Figure 2) were inoculated with 120 mL of anaerobic sludge and 120 mL of culture medium DSMZ 113, which has thiosulfate as a substrate, nitrate as the final electron acceptor, and bicarbonate as an inorganic carbon source. The thiosulfate consumption was monitored and after substrate depletion, 50% of the trickling solution was drawn off and fresh DSMZ 113 medium was added in the following 9 cycles. Different initial concentrations of thiosulfate (2.5, 5.0 and 10 g·[$S\text{-}S_2O_3^{2-}$]·L^{-1}) were applied. The system was operated under batch mode for 130 days (total of 10 cycles) at pH 7.0 by adding NaOH, temperature 35 °C and trickling medium at a flow rate of 500 mL·h^{-1}. The immobilized biomass was determined as gram of protein per gram of dry support sampled in the end of the experiment.

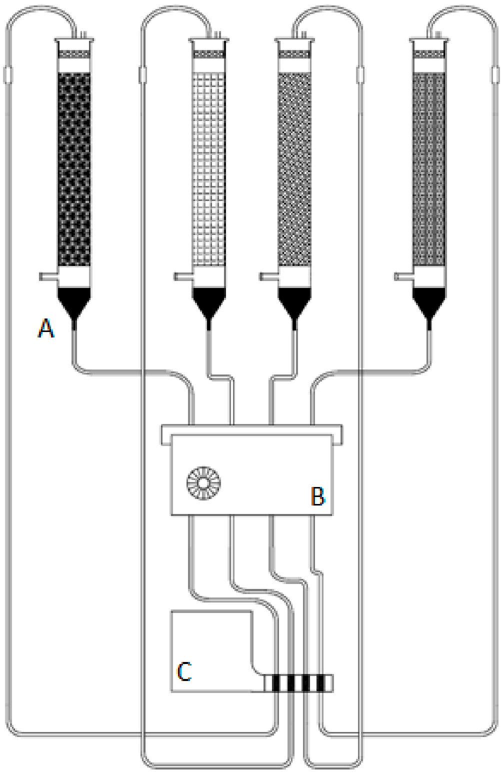


Figure 2. Experimental system: (**A**) Glass columns packed with different support materials; (**B**) water bath that maintained the temperature of the trickling medium at 35 °C; and (**C**) four-channel peristaltic pump.

2.3. Experimental Set-Up of a Laboratory-Scale Biotrickling Filter

The H_2S elimination from the biogas produced by a Sewage Treatment Plant (Matão, São Paulo, Brazil) was performed using a laboratory-scale biotrickling filter made of glass (active height of

456 mm, inner diameter of 93 mm and working volume bed of 3 L) filled with PVC pieces (Figure 3), obtained from construction pipes, as packing material. The experiments were carried out for 111 days with continuous biogas supply from the up flow anaerobic sludge blanket reactor (UASB).

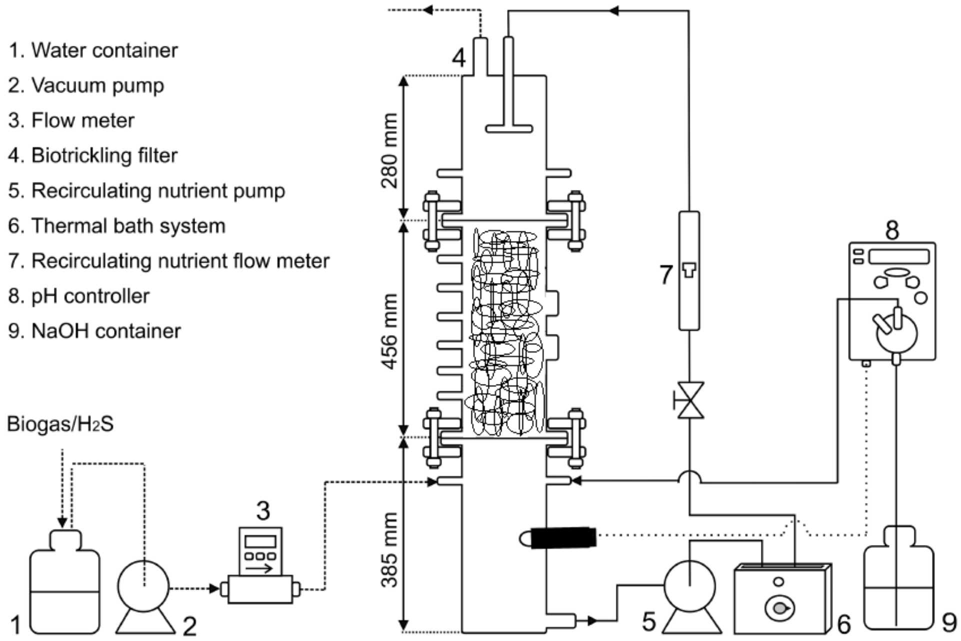


Figure 3. Representation of the biotrickling filter, adapted from Guerrero and Bevilaqua [19].

The first step of reactor operation consisted of inoculation and biofilm development providing H_2S containing biogas as the energy source (1246 ± 305 ppmv). Biofilm development was achieved after 43 days of operation and the degree of immobilization was determined by the stability of the substrate consumption [33]. The effects of the parameters, inlet load (from 8 to 108 $gS \cdot m^{-3} \cdot h^{-1}$), empty bed residency time (4.8, 2.4, 1.6 min), and temperature (from 24 to 40 °C), were studied in the following 68 days of operation.

2.4. Analytical Techniques

The H_2S concentration in the gas phase was measured using GasAlertMicro 5 Series—BW Technologies. The thiosulfate determination was carried out by an iodometric method [34]. Sulfate concentration was determined using a turbidimetric method and nitrate and nitrite concentrations were analyzed by an ultraviolet spectrophotometric method and a colorimetric method, respectively [35]. The amount of biomass immobilized on the packing material was estimated via determining protein by Lowry method [35].

3. Results and Discussion

3.1. Evaluation of Low-Cost Packing Materials

All four packing material tested showed similar thiosulfate RE (between 82 and 86%) at the end of first cycle of rector operation. However, at the end of the last cycles, PVC (96.67%) and PET (96.43%) presented better results compared to Teflon (25.37%), which suffered bed compaction. Additionally, the RE obtained using PVC and PET almost reached the value obtained for OPUF (99.17%). On the other hand, the biomass protein quantification showed that the mass of protein per mass of support material was very similar for PVC (14.9 $mg \cdot g^{-1}$) and Teflon (14.87 $mg \cdot g^{-1}$) (Figure 4), however, as mentioned before, Teflon became compacted during the experiment. PET had a lower amount of protein (8.40 $mg \cdot g^{-1}$) and all support materials presented lower biomass protein when compared with open-pore polyurethane foam (26.59 $mg \cdot g^{-1}$).

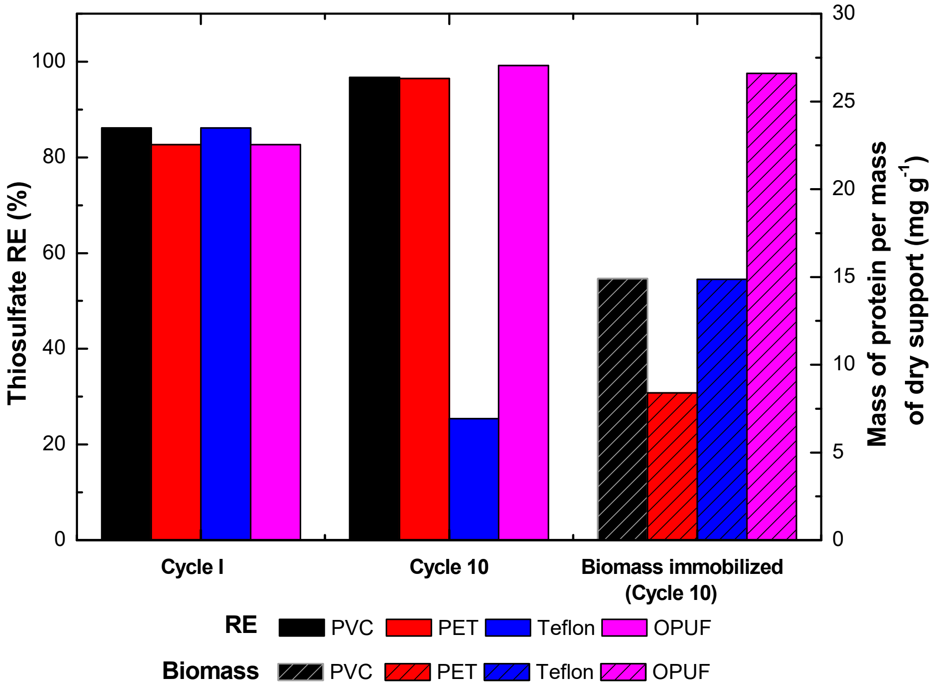


Figure 4. Thiosulfate Removal efficiency and biomass immobilized on the packing material after 10 cycles.

The cost to fill the working volume of the columns were: OPUF ($0.67 dollar), PVC ($0.21 dollar), PET ($0.0 dollar because it was from cycling residue) and Teflon ($0.36 dollar). Comparing the results, it was possible to suppose that PVC could provide better robustness to the system than PET, in case of adverse conditions, and other important factor is the cost of the PVC, 42% cheaper than Teflon and 69% cheaper than OPUF. For this reason, it was selected as packing material for the next experiment using a biotrickling filter to treat real biogas in bench scale.

3.2. Biotrickling Filter Operation

During the first 70 days of operation (including the inoculation and biofilm development step) the EBRT applied was 4.8 min and the inlet load provided to the reactor was 15.5 ± 3.09 gS·m^{-3}·h^{-1}. In these conditions a removal efficiency (RE) of 80.06 ± 13.81% was observed (Figure 5), lower than experiments with lower EBRTs of 2.4 min (RE = 71.89 ± 14.33%; IL = 39.9 gS·m^{-3}·h^{-1}) and 1.6 min (RE = 89.83 ± 14.97%; 57.9 gS·m^{-3}·h^{-1}). These results reflected the impact of the biofilm development step to elimination capacity in this operating condition, showing that, after stabilization, the biotrickling filter was capable of achieving a better RE even with a lower retention time. After stabilization, the system showed a high RE despite the low EBRT (1.6 min) and high H_2S concentration (1832 ± 295 ppmv), demonstrating that this bioreactor requires good biofilm development to achieve high EC in a real treatment which presents fluctuations over time.

The elimination capacity of the system obtained under different EBRTs was very high (Figure 6) reaching 84.4 gS·m^{-3}·h^{-1} (RE = 99%) at an EBRT of 1.6 min. The results obtained with this support material were comparable with results found in the literature for the most common materials used, such as OPUF [18,36] and Pall rings [9], demonstrating that it has potential for larger scale application. As stated previously, using OPUF, Fernández et al. [18] obtained a critical elimination capacity of 130 gS·m^{-3}·h^{-1} at an EBRT of 2.4 min. In the present work, the critical EC was not obtained due to system limitations, but the results were promising considering that PVC has the advantage of being a low-cost material, increasing the biotrickling filter economic viability. The points with different behavior (Figure 6) probably occurred due to H_2S inlet load fluctuations, since the biogas supplied in the system was obtained from a real sewage treatment plant from a city with approximately 90 thousand inhabitants. Therefore, the system, in this dimension of operation, was not robust enough to absorb these variations. Additionally, the three points (marked with arrows) with the lowest elimination capacity (two in 2.4 min and one in 1.6 min of EBRT) was affected by the weather which reached 39 °C in the first case and 27 °C in the second case, destabilizing the process due to temperature sensitivity.

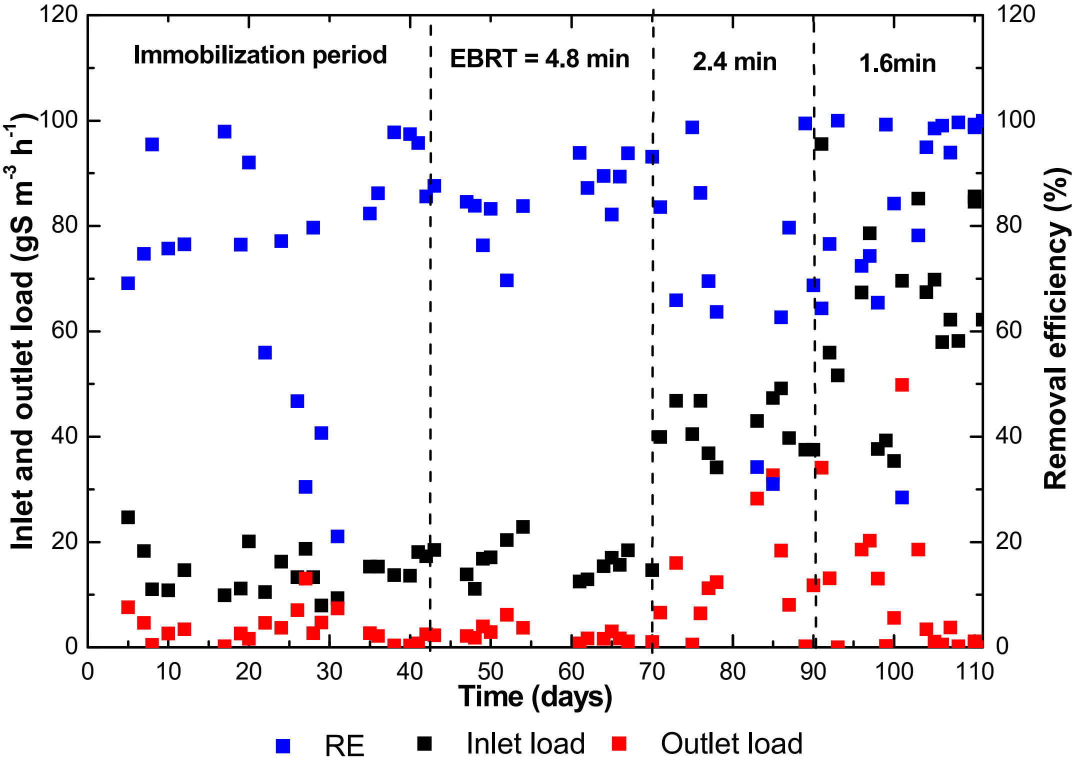


Figure 5. Removal efficiency and inlet and outlet loads during 111 days of biotrickling filter operation.

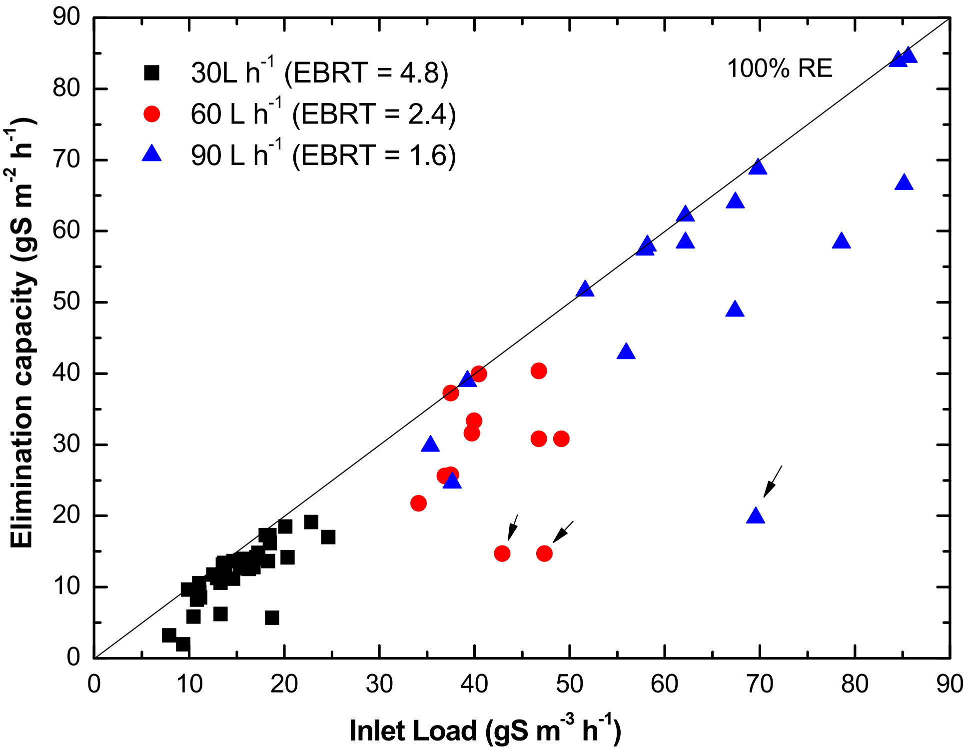
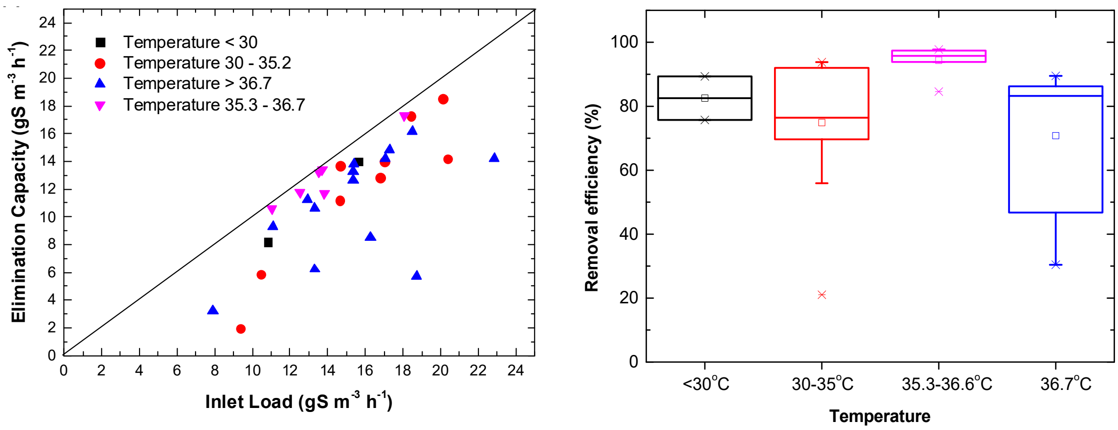


Figure 6. Elimination capacity of the biotrickling filter under different EBRTs.

The temperature effect was analyzed in the first 70 days of operation and as shown in Figure 7a, all ranges of temperatures presented Inlet Loads between 8 and 23 gS·m^{-3}·h^{-1} and also reached ECs higher than 14 gS·m^{-3}·h^{-1} in the operational conditions. It is important to emphasize that despite presenting similar EC behavior for all temperature ranges, the highest RE and lowest variations were obtained for temperatures from 35.5 to 36.7 °C, and temperatures outside this range presented both high distancing from the 100% line and more variations, showing that the system may be outside its optimal condition. This is an important factor for biological H_2S removal systems and the optimum obtained was 36 ± 0.7 °C in which the RE observed was 95.72 ± 4.50%. Temperature ranges from 30.0 to 35.2 °C presented REs of 76.31 ± 13.92% and temperatures higher than 36.7 °C demonstrated a RE of 83.50 ± 21.65% (Figure 7b).



(**a**) (**b**)

Figure 7. Effect of temperature on the (**a**) elimination capacity and (**b**) removal efficiency. The data include inter-quartile deviations and medians (larger box), (□) average values, (x) outliers and (-) maximum (upper whisker) and minimum (lower whisker) limits of non-discrepant values.

The results obtained using PVC pieces, as an alternative support, presented similar removal efficiency when compared to commercial supports. Table 3 shows a comparison of operation parameters and results from the present work with another study using the same reactor filled with OPUF as support material [19]. It is possible to observe that, for most of the operating time, the biotrickling filter packed with OPUF was operated under low IL and the biotrickling filter with PVC under high IL and despite this, the latter reached similar RE. As a comparison, the system with PVC when submitted to lower IL (12.82 ± 2.47 gS·m^{-3}·h^{-1}) at an EBRT of 1.6 min showed an RE of 87.18%. Other alternative support materials such as "Raschig Ceramic Rings", presented a lower RE (75%) under similar operational conditions [37].

Table 3. Comparison of results from different parameters in a biotrickling filter packed with PVC pieces and OPUF.

Parameter	PVC Pieces Present Study	OPUF [18]
Energy source for immobilization	H_2S from biogas	$Na_2S_2O_3 \cdot 5H_2O$
Nitrate concentration (g·N-NO_3^-·L^{-1})	0.25–8.0	0.25–2.0
EBRT (min)	1.6, 2.4 and 4.8	1.6, 2.9 and 6.2
TLV (m·h^{-1})	8–11	4.4, 7.4 and 11
Temperature (°C)	24–40	22–47
H_2S Inlet Load (gS·m^{-3}·h^{-1})	8–108	2–16
Elimination Capacity (gS·m^{-3}·h^{-1})	84.4	14
Removal Efficiency (%)	95.72 (IL = 67.38 ± 17.74 gS·m^{-3}·h^{-1}), EBRT = 1.6 min)	98 (IL = 6.13 ± 0.49 gS·m^{-3}·h^{-1}, EBRT = 2.9 min)

The IL applied to the PVC system was from 4 to 6.75 times higher than that applied to the OPUF system, providing conditions to reach 84.4 $gS \cdot m^{-3} \cdot h^{-1}$ of EC, 6 times higher than the EC obtained using OPUF under lower IL. Although under optimal conditions, both PVC and OPUF reached RE values higher than 95%, what is remarkable is that PVC presented this RE even under an IL 137 times higher than OPUF. Both systems, even in the small dimensions studied, demonstrated robustness with high elimination capacity under real industrial conditions, which means seasonal differences in temperature, operation problems, and not controlling the H_2S concentration coming from the treatment plant. It is worth highlighting PVC as an alternative packing material for potential application in larger scales, reducing the initial process costs, which has a high impact considering the amount of packing material required for higher inlet load from real industrial sources

4. Conclusions

The use of biotrickling filtration as a biological technology for biogas biodesulfurization is consolidated as an effective and promising alternative. Nevertheless, the cost savings for the application of this technology, especially in developing countries, is a concern for researchers in order to make it accessible to a greater number of companies. The challenge is to find a packing material with the necessary features for this operation. In a comparative study in columns utilizing four different packing materials, strips of Polyvinyl Chloride (PVC) presented similar efficiency to OPUF, a recognized packing material for decontamination of gases. PVC-biotrickling filter was compared with OPUF- biotrickling filter. Although both had the same dimensions, each filter was assembled in a different place; the PVC-biotrickling filter was coupled to an output of H_2S from a Sewage Treatment Plant (Matão, São Paulo, Brazil) and the other coupled to a wastewater treatment plant of a brewery. Both biotrickling filters presented high elimination capacity; however, the PVC-biotrickling filter was submitted to more aggressive conditions, such as higher IL and temperature variations, maintaining good performance throughout operation time. Thus, PVC can be stated as a potential low-cost packing material for decontamination of industrial gases containing H_2S in a biotrickling filter system.

Author Contributions: D.B. and R.d.B.S.G. conceived and designed the experiments. S.P.T. and L.F.H. performed the experiments. All authors contributed to analyses of data. S.P.T., R.d.B.S.G. and D.B. wrote the paper.

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