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PE19) Treatment of Hydrogen Sulfide in Waste Gas Stream by Polyurethane Biotrickling Filter

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1. INTRODUCTION

Hydrogen sulfide is nuisance odor smelling like a rotten egg, released to the atmosphere as a by-product of industrial process including sour gas flaring, wastewater treatment and pulp and paper manufacturing. The biological removal of hydrogen sulfide has been studied by a number of researchers, Seongyup Kim, Marc A.Deshusses (2005) suggested that trickling rate was significant effect on high gas velocity, and addition of some sulfur containing substrates, such as thiosulfate had an improved effect on removal of hydrogen sulfide. Investigation of microbial diversity in system is important, due to changing operational parameters, such as pH. At the neutral pH the mixed cultures grown had intrinsically effective. While in some studiessuggested that even at low pH removal of hydrogen sulfide is less affected due to acidophilic characteristic of inoculates. Yaomin Jin et al., (2005) studied the autotrophic degradation of sulfide in biotrickling filter signifying influence of CO_2, pH and flow pattern on the removal of hydrogen sulfide. They suggested that neutral pH was effective for the autotrophic degradation with an elimination capacity of 31.12g H_2S/m^3h; removal efficiency 97%. Complete removal of hydrogen sulfide were at 11s EBRT. David Gabriel, Marc A.Deshusses (2003) studied hydrogen sulfide removal in converted biotrickling filter, and suggested that even at low EBRT as 1.6 95% of H_2S were removed for sustained inlet as 30 ppm. 90% removal observed at 2.2s with 60ppm of inlet concentration.

In the present study a biotrickling filter was packed with polyurethane foam as support used to treat H_2S-polluted air, and to determine the operating parameters that optimize the performance of system.

2. MATERIALS AND METHODS

2.1 Experimental set-up

Two identical laboratory set-ups were applied for the removal of hydrogen sulfide. Both of columns were inoculated sulfur oxidizing bacteria. One reactor was running with deionized water, the other one were operated with secondary effluent water from waste water treatment plant (Yong-in city, Korea). Biotrickling filter construction and operating conditions are shown in Table 1 and Figure 1. H_2S was introduced by reaction of HCl and solution of Na_2S. H_2S concentrations ranging from 0 to 200 ppm were obtained by changing the Na_2S concentration and/or the dripping rate.

2.2 Microorganisms and cultivation

Sulfide oxidizing bacteria were enriched in initially autoclaved thiosulfate media at 150rpm 28^0C. The composition of the liquid medium used was (in g/L): KH_2PO_4, 2; K_2HPO_4, 2; NH_4Cl, 0.4; $MgCl_2.6H_2O$, 0.2; $FeSO_4.7H_2O$, 0.01; $Na_2S_2O_3.5H_2O$, 8 and yeast 1. Autoclaved polyurethane foams were introduced to the flask with enriched microorganisms and also incubated at same condition. After 7 days of incubation foams were transferred to columns and drained liquidmedia for 24hours.

Table 1. Operating condition

Design	
Bed height and internal diameter	30×10 cm^2
Bed volume	3L
Packing	Polyurethane foam (90% porous)
Recycle liquid volume	2L
Gas/liquid flow	Counter current
pH control	Manual addition of 0.3M NaOH; 1M HCL
Operation	
Gas flow rate (EBRT)	5~8L h-1 (36~10s)
Mass loading	6~43 g m-3 h-1
H2S inlet concentration	Variable, up to 200 ppmv
Recycle liquid pH	7.0
Recycle liquid rate	250 ml/,in
Nutrient addition	250ml/day

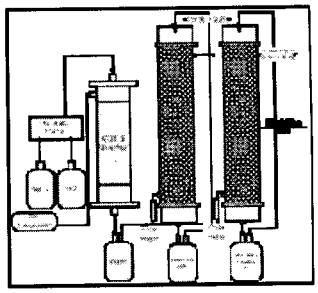

Fig. 1. Biotrickling filter.

2.3 Analytical methods

H_2S were measured by Gastec and multiRae portable gas analyzer; t^0 were determined by thermometer and pH by pH meter. Pressure drop were measured by digital manometer. Sulfide concentration in liquid determined by methylene blue method using s auto analyzer AA3 (Bran Luebbe, Germany) and CFU by serial dilution method. Sulfate ions measured by ion chromatography (Waters).

3. RESULTS AND DISCUSSIONS

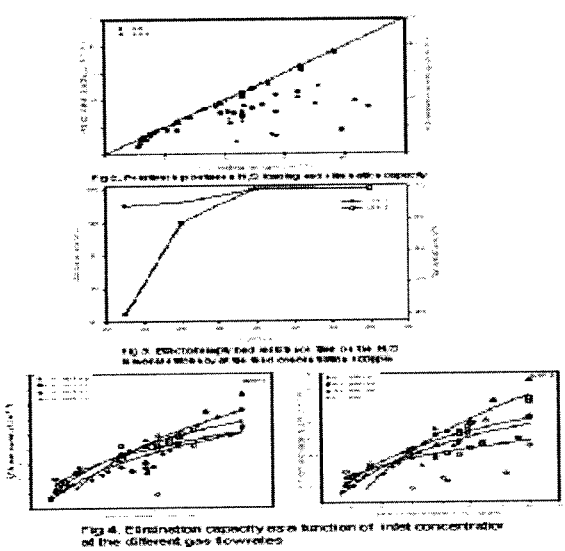

Fig 4. Elimination capacity as a function of inlet concentration at the different gas flowrates

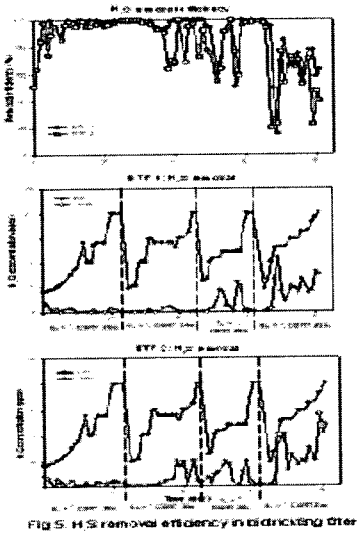

Fig 5. H_2S removal efficiency in biotrickling filter

3.1 Gas analyses

At the start upin both systems inlet concentrations were maintained near 50ppm. After 7 days of start up removal efficiency in both reactors were 100%. When the concentration increased to 100 ppm, removal efficiency in both reactors maintained above 98%. For BTF 1, the removal efficiency was higher than BTF 2 even at the high concentration as 200ppm. With the increasing gas flow rate the removal efficiency were stable at a low concentrations but at high concentrations it decreased to 60%.In BTF 2 the nutrient addition were stopped after 20 days and only replaced

trickling water with 500ml/day secondary effluent water. At day 35, the removal efficiency decreased to 62%, which can be explained that nutrients which were fed previously all consumed by microorganisms. Although the secondary effluent water has buffering effect but it's needs also constant nutrient addition.

3.2 H_2S removal efficiency

Increasing H_2S concentrations were fed to the biotrickling filter to establish operating criteria necessary to scale-up the biotrickling filter, the relationship between the inlet loading of H_2S and the elimination capacity was estimated. The results are reported in Fig. 2. The elimination capacity is defined as the amount of pollutant degraded per unit of time, normalized to the volume of packed bed. As shown in Fig. 2, the critical loading (i.e complete removal capacity) was determined as 32.88 g H_2Sm^{-3} reactor h^{-1} with 100% removal efficiency for each biotrickling filters.

3.3 Effect of EBRT/ gas flow rate on the removal of H_2S

The effect of empty bed residence time were studied at gas feed concentration 100 ppm, with a different gas flow rate. The removal efficiency reached above 95% removal at 36s (EBRT). When it decreased to 23s the removal efficiency was still high at low inlet concetrations (~100ppm) but at a high ·inlet concentration removal efficiency decreased to 60% and 20% for BTF 1 and BTF 2, respectively. The reduction in removal efficiency can be explained by the slow diffusion of gas into liquid phase.After sometime the removal efficiency increases again, which means the microorganisms adapts to the new environment. The optimum EBRT for both reactors obtained at 26s .

In Fig. 4, the measured trickling filter's elimination capacity is plotted for different inlet H_2S concentrations at a constant liquid flow rate of 250ml/min and at gas flow rates of 5, 6, 7 and 8L min^{-1} corresponding to EBRTof 36, 30, 26 and 23 s. From this figure, it can be observed that the elimination capacity increased when increasing the gas flow rate over all the concentration range studied. At 7L min^{-1} a maximum elimination capacity of 38.36 g H_2 Sm^{-3} h^{-1} for BTF 1 and 37.78 g H_2S $m^{-3}h^{-1}$ for BTF 2 was obtained.

REFERENCES

[1] Yaomin Jin, Maria C. Veiga and Christian Kennes. (2005) Autotrophic deodorization of hydrogen sulfide in a biotrickling filter, J Chem Technol Biotechnol 80:9981004.

[2] Huub H.J.Cox, Marc A.Deshusses. (2001) Co-treatment of H_2S and toluene in biotrickling filter, Chemical Engineering Journal 3901:110.

[3] Seongyup Kim and Marc A.Deshusses. (2003) Development and experimental validation of conceptual model for biotrickling filtration of H_2S, Environmental Progress 22(2), 119-127.

[4] Yaomin Jin, Maria C. Veiga and Christian Kennes. (2005) Effects of pH, $CO_2$and flow pattern on the autotrophic degradation of hydrogen sulfide in biotrickling filter, Wiley Peridicals, Inc., Biotechnology and Bioengineering, Vol. 92, Issue 4, 462-472.

[5] Huiqi Duan and Lawrence Choon Chiaw Koe., Investigation on the mechanisms of H_2S by biological activated carbon in horizontal biotrickling filter.,

[6] David Gabriel and Marc A. Deshusses. (2003) Performance of full-sclae biotrickling filter H_2S at a gas contact time of 1.6 to 2.2 seconds, Environmental progress 22(2), 111-118.