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Water Scrubbing for Removal of Hydrogen Sulfide (H_2S) Inbiogas from Hog Farms

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Abstract

Biogas from anaerobic digestion of biological wastes is a renewable energy resource. H_2S in biogas may cause corrosion or other damage to engines if it is not removed from the gas before utilization. Because the solubility of H_2S in water is higher than methane, water can be used as an adsorbent to remove H_2S from biogas. A simple water scrubbing column to reduce the H_2S content was designed in this study. The biogas purification process took place in the scrubbing column with water where the gas was continuously fed from the bottom of the column through the diffuser which could produce bubbles. The biogas bubbles and the water can accelerate the reaction inside the column. The water in the column was circulated by means of a pump. H_2S content in raw biogas was about 6000 ppm. First, the efficiencies of H_2S removal for different biogas flow rate and water level were conducted at 30 and 90 sec. Second, the efficiencies of H_2S removal with water recycling system were induced. The results showed that the concentration of H_2S in biogas decreased significantly with water level and increased with biogas flow rate through the water scrubbing. It was an effective technique for removing H_2S in a short operation time, but absorption capability of water declined rapidly with time. To maintain high absorption rate, water scrubbing after adsorption needed to be replaced or regenerated. The water scrubbing system is a simplest and cheapest method. This work is investigated the feasibility of water scrubbing system and its application to a small hog farm.

Keywords

Biogas; Hydrogen Sulphide; Water Scrubber

1. Introduction

Biogas is produced by the anaerobic digestion or fermentation of biodegradable materials such as biomass, manure, sewage, municipal waste and plant materials. Biogas is a renewable energy source and can replace fossil fuel. Anaerobic digestion is often the only possibility of producing biogas from manure. By definition, anaerobic digestion is a microbiological process during which organic matter is decomposed into biogas and microbial biomass in the absence of air. There has been growing interest in biogas which is bio-energy source resulting

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from the conversion of natural biomass. The major portion of biogas is carbon dioxide (CO_2), ammonia (NH_3), hydrogen sulfide (H_2S) and methane (CH_4), of which hydrogen sulfide apparently is the most toxic to both humans and animals. Agricultural by-products are often the problem of environmental pollution and affect human health. The major source of methane contained in the atmospheric is agricultural activities, including straw and cattle, pigs and other livestock. Theoretically, the methane productivity can be measured in terms of volatile solids (VS). The theoretical methane productivity is higher in pig (516 $l \cdot kg^{-1}$ VS) and sow (530 $l \cdot kg^{-1}$ VS) manure than in dairy cattle manure (468 $l \cdot kg^{-1}$ VS) [1].

Biogas production has the potential to be an efficient means of emphatically decreasing greenhouse gas emissions in a number of areas of the animal production life cycle [2]-[4]. If the amount of manure produced by a fattening pig is 0.13 ton organic material (volatile solids, VS) per fattening pig place and year, this could produce around 0.29 MWh biogas per year [5]. One of the biggest factors limiting for the use of biogas is related to the hydrogen sulfide content, which is very corrosive to internal combustion engines [6] [7]. Most of the commercial technologies for the removal of H_2S content are chemically based and expensive to operate [8]-[10] thereby reducing the economic value of use of the biogas. The easiest method of biogas purification is water scrubbing which uses of the characteristics of hydrogen sulfide soluble in water [11].

This study intends to design a simple desulfurization equipment of water scrubbing to reduce the hydrogen sulphide content of the biogas. Pressurized biogas through the aeration plate to produce many small biogas bubbles and the bubbles will full contact with water in order to achieve adsorption effect of desulfurization. A simple water scrubbing column to reduce the H_2S content was designed in this study. Different water levels and biogas flow rate were conducted to detect hydrogen sulphide content in biogas after water scrubbing, and then investigate the desulfurization efficiency of biogas purification.

2. Materials and Methods

The test of desulfurization in biogas was conducted in a hog farm with feeding 700 pigs. Biogas produced from anaerobic digestion processes of the three-stage waste-water of pig's manure. The energy source of lamp using biogas-combustion was used to keep warm of weaned pigs. A desulfurization equipment of water scrubbing with a transparent acrylic cylinder column (diameter as 0.248 m and height as 1.2 m) was designed to observe the situation of desulfurization in biogas. The water were transported into transparent acrylic cylinder column at the upper inlet, the water level could be measured. The water drained away at the bottom outlet and accomplished circulating water system. The aeration plate was placed in the bottom of the column and the biogas will be pressurized into the column as small bubbles to sufficient contact with water to remove the hydrogen sulfide in biogas by positive way with pressure machine. The biogas flow rate could be measured by flow meter before biogas into the aeration plate.

The concentrations of hydrogen sulfide will be measured at the upper outlet of biogas by the detection device (range 500 ppm - 12000 ppm) which is composed of gas taking implement and detection tubes at the measured area of upper outlet. The schematic of desulfurization in biogas using water scrubbing showed in **Figure 1** Then, the circulating water system was set on the basis of the original desulfurization equipment of water scrubbing to avoid the water of the column saturated that maintain a stable removal efficiency of the hydrogen sulfide. The aeration plate and the small biogas bubbles in the water column are shown in **Figure 2**.

The test of water scrubbing would be conducted with the different water level (50, 60 and 70 cm) of the column and the flow rate (50, 100 and 140 l/min) of the biogas. The concentrations of hydrogen sulfide will be detected at the upper outlet of biogas after the water scrubbing time as 90 sec and 30 sec, and whether the circulating water system was induce to investigate the removal efficiency of desulfurization of water scrubbing. The removal efficiency was calculated as follow equation.

$$\text{Removal efficiency } (\%) = \left[(A - B) / A \right] * 100 \quad (1)$$

where A: the concentration of H_2S (before water scrubbing) (ppm), B: the concentration of H_2S (after water scrubbing) (ppm).

3. Results and Discussion

The results of removal efficiency of H_2S content for biogas in different water level with biogas flow rate 140 *l*/min after water scrubbing 30 sec and 90 sec were shown as **Table 1**and **Table 2** which was clearly indicated

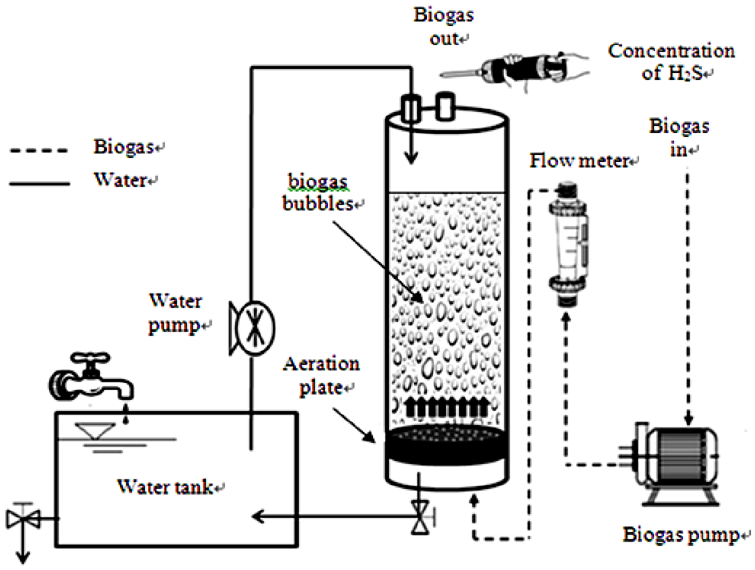

Figure 1. Schematic of desulfurization in biogas using water scrubbing.

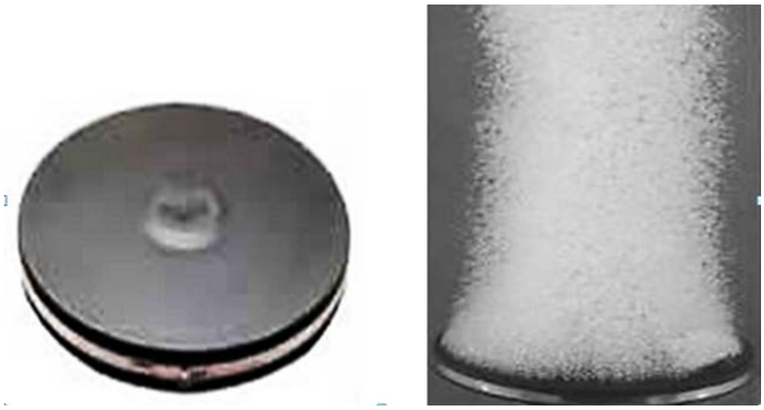

Figure 2. The aeration plate and the small biogas bubbles in the water column.

Table 1. The removal efficiency of H_2S content for biogas in different water level with biogas flow rate 140 *l*/min after water scrubbing of 30 sec.

Water scrubbing time(sec)		30	
Water level (cm)	50	60	70
Trial	3	3	3
Concentration of the H_2S (ppm)	4000.0	3633.3	2933.3
The removal efficiency *(%)	33.3 ± 7.6	39.4 ± 14.3	51.1 ± 9.8

*Without circulating water system.

Table 2. The removal efficiency of H_2S content for biogas in different water level with biogas flow rate 140 l/min after water scrubbing of 90 sec.

Water scrubbing time(sec)		90	
Water level (cm)	50	60	70
Trial	3	3	3
Concentration of the H_2S (ppm)	5233.3	4766.7	4466.7
The removal efficiency *(%)	12.8 ± 8	20.6 ± 4.8	25.6 ± 7

*Without circulating water system.

that the removal efficiency of H_2S content for biogas was increased with the height of the water level at water scrubbing time of 30 sec and 90 sec. The removal efficiency of H_2S content for biogas at time 30 sec was higher than time 90 sec. It reveals that the average removal efficiency was 51% at the scrubbing time and water level as 30 sec and 70 cm but drops to remaining 26% after scrubbing time 90 sec. The removal efficiency of H_2S content for biogas in different water level without circulating water system was shown as **Figure 3** The removal efficiency of H_2S content for biogas was decreased due to the concentration of dissolved hydrogen sulphide was saturated with the increased of water scrubbing time.

The results of removal efficiency of H_2S content for biogas in different biogas flow ratewith water level 60 cm after water scrubbing of 30 sec and 90 sec was shown as **Table 3** and **Table 4** which was clearly indicated that the removal efficiency of H_2S content for biogas was decreased with biogas flow rate at water scrubbing time of 30 sec and 90 sec. The removal efficiency of H_2S content for biogas at time of 30 sec was higher than time 90 sec. It reveals that the removal efficiency of H_2S content for biogas was 78% at the scrubbing time and biogas flow rate as 30 sec and 50 l/min but drops to remaining 59% after scrubbing time of 90 sec. The removal efficiency of H_2S content for biogas in different biogas flow rate without circulating water system was shown as **Figure 4**. It could be clearly summed up that the removal efficiency of washing time as 30 sec was better than 90 sec that showed the desulfurization of water scrubbing equipment should be established the circulating water system to get stable removal efficiency.

The relationship of removal efficiency of H_2S content for biogas and water scrubbing time at biogas flow rate as 50 l/min and water level as 60 cm was shown as **Figure 5**. It reveals that the removal efficiency of H_2S was near 0 % after scrubbing time 6 min without circulating water system, butthe removal efficiency of H_2S was about 30% after scrubbing time 6 min for circulating water system with 7.2 l/min flow rate.

The water in the column adsorbed hydrogen sulfid was emissions into the tank and the clean water of the circulating water system was flown into the column by pump that make sure the desulfurization of water scrubbing equipment could be recycled and adsorbed hydrogen sulfide in order to maintain the removal efficiency.

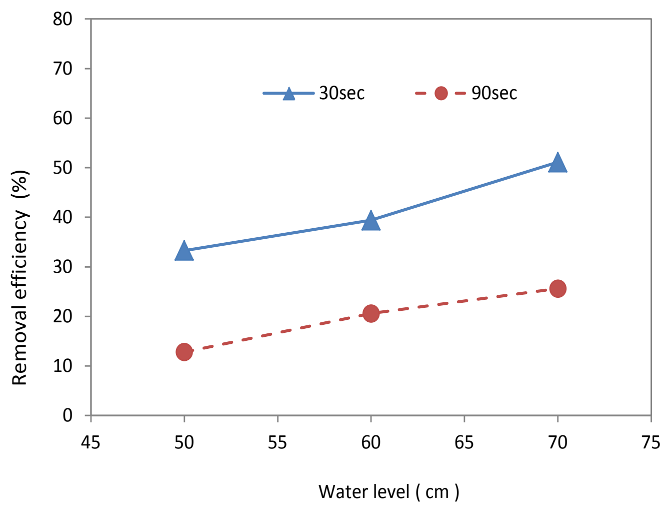

Figure 3. The removal efficiency of H_2S content for biogas in different water level without circulating water system.

Table 3. The removal efficiency of H_2S content for biogas in different biogas flow rate with water level 60 cm after water scrubbing of 30 sec.

Water scrubbing time (sec)		30	
Water level (cm)	50	100	140
Trial	3	3	3
Concentration of the H_2S (ppm)	1300.0	2100.0	3633.3
The removal efficiency *(%)	78.3 ± 1.4	65 ± 5.9	54.4 ± 11

*Without circulating water system.

Table 4. The removal efficiency of H_2S content for biogas in different biogas flow ratewith water level 60 cm after water scrubbing of 90 sec.

Water scrubbing time(sec)		90	
Water level (cm)	50	100	140
Trial	3	3	3
Concentration of the H_2S (ppm)	2433.3	2833.3	4766.7
The removal efficiency *(%)	59.4 ± 5.7	52.8 ± 7.9	30.6 ± 14.6

*Without circulating water system.

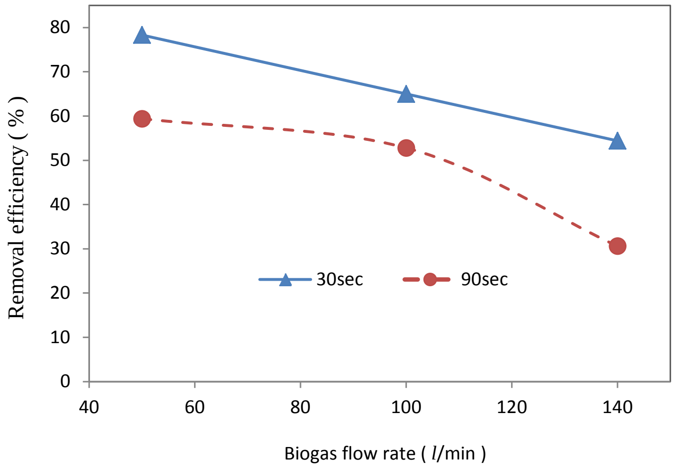

Figure 4. The removal efficiency of H_2S content for biogas in different biogas flow rate without circulating water system.

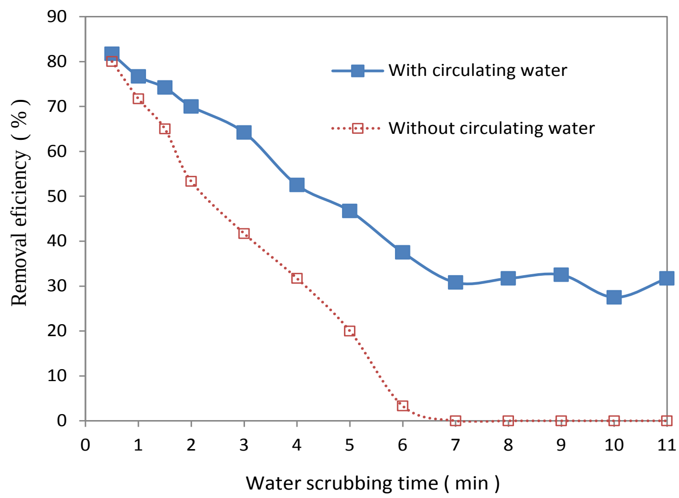

Figure 5. The relationship of removal efficiency of H_2S content for biogas and water scrubbing time.

4. Conclusion

Due to the hydrogen sulfide was easy to dissolve in the water for the higher water level and smaller biogas flow rate could increase the scrubbing time that hydrogen sulphide reacted with the water. Then, the removal efficiency of hydrogen sulphide was increased with the height of water level and decreased with the biogas flow rate. Therefore, the removal efficiency will better with high water level and small biogas flow rate, but decrease with the scrubbing time because of the water saturation. However, it can be improved by setting the circulating water system that it can continue to absorb the hydrogen sulfide.

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References

[1] Møller, H.B., Sommer, S.G. and Ahring, B.K. (2004) Methane Productivity of Manure, Straw and Solid Fractions of Manure. *Biomass and Bioenergy*, **26**, 485-495. http://dx.doi.org/10.1016/j.biombioe.2003.08.008

[2] Monteny, G.J., Groenestein, C.M. and M.A. (2001) Interactions and Coupling between Emissions of Methane and Nitrous Oxide from Animal Husbandry. *Nutrient Cycling in Agroecosystems*, **60**, 123-132. http://dx.doi.org/10.1023/A:1012602911339

[3] Pipatmanomai, S., Kaewluan, S. and Vitidsant, T. (2009) Economic Assessment of Biogas-to-Electricity Generation System with H_2S Removal by Activated Carbon in Small Pig Farm. *Applied Energy*, **86**, 669-674. http://dx.doi.org/10.1016/j.apenergy.2008.07.007

[4] Zhou, J.B., Jiang, M.M. and Chen, G.Q. (2007) Estimation of Methane and Nitrous Oxide Emission from Livestock and Poultry in China during 1949-2003. *Energy Policy*, **35**, 3759-3767. http://dx.doi.org/10.1016/j.enpol.2007.01.013

[5] Berglund, M. and Börjesson, P. (2003) Energianalysavbiog as System. Rapport 44. Miljö-ochenergisystem, Lundstekniskahögskola.

[6] Ross, C.C., Drake, T.J. and Walsh, J.L. (1996) Handbook of Biogas Utilization, 2nd. SERBEP, c/o General Bioenergy, Florence, AL.

[7] Tchobanoglous, G., Burton, F.L. and Stensel, H.D. (2003) Wastewater Engineering. Treatment and Reuse, 4th Edition, McGraw-Hill Companies, New York, NY, USA, 1505-1532.

[8] Monteith, H., Béland, M. and Parker, W. (2005) Assessment of Economic Viability of Digester Gas Cogeneration at Canada's Largest Wastewater Treatment Plants. *CD of Proceedings of the* 34*th Water Environment Association of Ontario Annual Conference*, Huntsville, ON.

[9] Gabriel, D. and Deshusses, A.M. (2003) Retrofitting Existing Chemical Scrubbers to Biotrickling Filters for H_2S Emission Control. *Proceedings of the National Academy of Science of the United States of America*, **100**, 6308-6312.

[10] Cha, J.M., Cha, W.S. and Lee, J.H. (1999) Removal of Organo-Sulphur Odor Compounds by *Thiobacillus novellas* SRM, Sulphur-Oxidizing Microorganisms. *Process Biochemistry*, **34**, 659-665. http://dx.doi.org/10.1016/S0032-9592(98)00139-3

[11] Lantela, J., Rasi, S., Lehtinen, J. and Rintala, J. (2012) Landfill Gas Upgrading with Pilot-Scale Water Scrubber: Performance Assessment with Absorption Water Recycling. *Applied Energy*, **92**, 307-314. http://dx.doi.org/10.1016/j.apenergy.2011.10.011