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Research on Feasibility of Mesophilic Anaerobic Digestion of Mixture of Grass Cutting's from Greenings and Sludge from Wastewater Plants

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Abstract: This paper studies the feasibility of joint digestion processing of grass cuttings from city greening and sludge from wastewater plant and selects respectively 10%, 20%, 30%, 40% and 50% dry weight percent for grass cutting's and sludge. The experimental results indicate that the gas production rate of the sludge digestion system will grow with growth of added grass cuttings. When the percentage of added grass cuttings is 50%, the gas production rate of the digestion system can reach 348 L/kg.TS, compared to the value without grass cutting. The gas production rate increases by 30%. Therefore, the joint digestion processing of the grass cuttings from sludge of wastewater plant is feasible.

Keywords: Gas production rate, lawn grass cuttings, mesophilic digestion, sludge.

1. INTRODUCTION

With improvements in the living quality of people, and construction demand for ecological cities, the greening areas of cities are increasing rapidly. As a result, the discarded greening wastes are gradually increasing year by year. These greening wastes are mainly used as the fertilizers. Most wastes will be burnt or buried as rubbish which pollutes the atmospheric environment and increases the processing workload of the dumps.

The sludge digestion features simple process operation with small sludge and recyclable biogas and this is a method which is frequently used to stabilize and reutilize the sludge from city sludge plants. The carbon and nitrogen ratio is low in the sludge digestion of the city wastewater processing plant, so it affects the activity of the anaerophyte and reduces the sludge digestion efficiency of the sludge digestion tanks. Research on the joint digestion processing of the kitchen wastes and city's sludge has been reported. The kitchen wastes such as vegetables are used for sludge digestion in order to assist the nutrition balance in sludge digestion and improve utilization rate and gas production rate of the digestion tank of the city wastewater plug [1-3]. The reports on city's greening wastes used for the sludge digestion of the city wastewater plant have been published.

With the grass cuttings for city greening as the typical greening waste, this paper studies feasibility of the joint anaerobic digestion of the grass cuttings and sludge from the wastewater plants and surveys its effect and influence factors to provide reference for the joint anaerobic digestion processing and scale applications of the greening wastes and sludge of the city wastewater plants.

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2. EXPERIMENTAL DEVICES AND METHODS

2.1. Experimental Device

The sludge anaerobic digestion system for the experiment is a self-made mesophilic sludge anaerobic digestion device, the working principle of which has been shown in Fig. (**1**). The digester is made of organic glass tube, which is 200 mm in diameter and 240 mm high and has 7.L capacity and 7L valid capacity. Total 6 digesters are available and are placed in a constant-temperature water batch tank (electric heating, automatic temperature control, 1200 mm long, 600 mm wide and 500 mm high). The relay and temperature sensors are used for constant-temperature control. The gas output tube at the top of the digester connects the wet gas flow meter to record the gas output volume. The gas storage bag is used to collect biogas and analyze the contents of biogas. The exhaust is purified by the gas cleaning tank and then discharged. The cleaning tank is installed with caustic soda solution to absorb the hepatic gas in the biogas. This gas is the highly toxic gas and will lead to safety accident if it is not processed, and stabilizes the operation pressure of the digestion system.

2.2. Experimental Scheme

First the system will start, take the sludge digestion from the digestion tank of the Haibo River wastewater plant, screen them, remove the big impurity particles, add 7L into each digester respectively for digestion, adjust the water temperature inside the tank to the designed temperature (35±1)°C, mix it for 60 min twice every day, keep the sludge recycling pump operating the whole day, and perform this experiment after the system has started to operate stably.

The system will feed in and out once every day. The raw sludge is taken from the pre-concentrated tank from the Haibo River wastewater plant. The average water content

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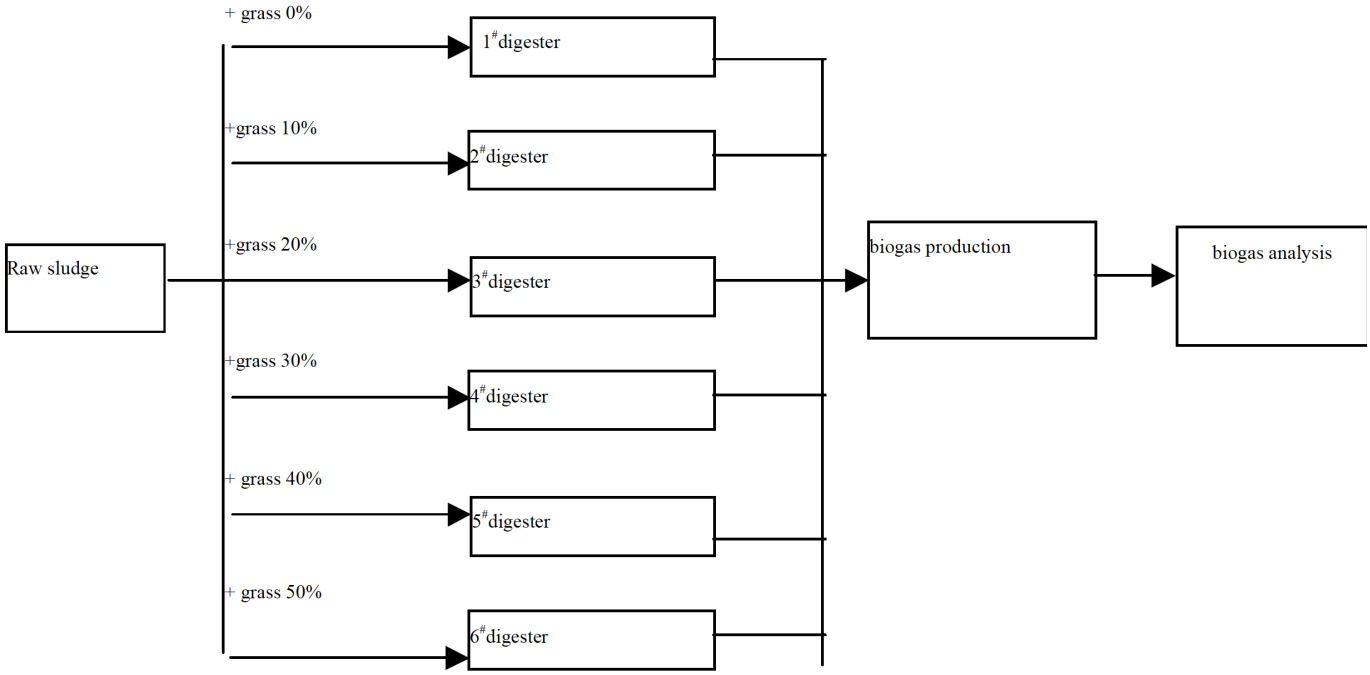


Fig. (1). The experimental plan.

rate of the raw sludge is 97%. The percent of the added raw sludge to the sludge in the digester is 8%.

The grass cuttings from the greenings yield a typical greening waste. 2~4 cm grass cuttings are selected. The added grass cuttings are 0%, 10%, 20%, 30%, 40% and 50% of the raw sludge (based on the dry weight), namely the added weight is 0 g, 1.68 g, 3.36 g, 5.04 g, 6.72 g and 8.40 g, respectively.

The experimental scheme is designed in Fig. (**1**).

The experimental device is shown as the Fig. (**2**).

After the grass cuttings are mixed with the raw sludge according to the design percent, the mixture is added from the raw sludge pipe (7) with the funnel and is stirred to fully mix the raw sludge and grass inside the tank.

The system's operating conditions are determined *via* the PH value and atmospheric pressure. The PH value and atmospheric pressure can indicate if the system can operate normally. When the system operation is abnormal, the PH value will decrease and the atmospheric pressure will reduce. The PH value and biogas will be detected once every day during the test and the atmospheric pressure will be observed once every day.

2.3. Measurement Method

The biogas content is measured according to "Chemical analysis method for main contents in artificial gas" GB/T 12205-1990 and is measured by using the QF1904 industry gas analyzer. CO_2 is absorbed by 30% KOH. The hydrocarbon contents are absorbed by 4:1 mixed liquid of the silver sulfate and nickel salt. The oxygen is absorbed by the pyrogallic acid and the CO is absorbed in the mixture of the cuprous chloride and stronger ammonia water. The hydrogen and methane are measured with the explosion method. The residual inertial contents are counted as N_2. The contents of the biogas are counted by percentage.

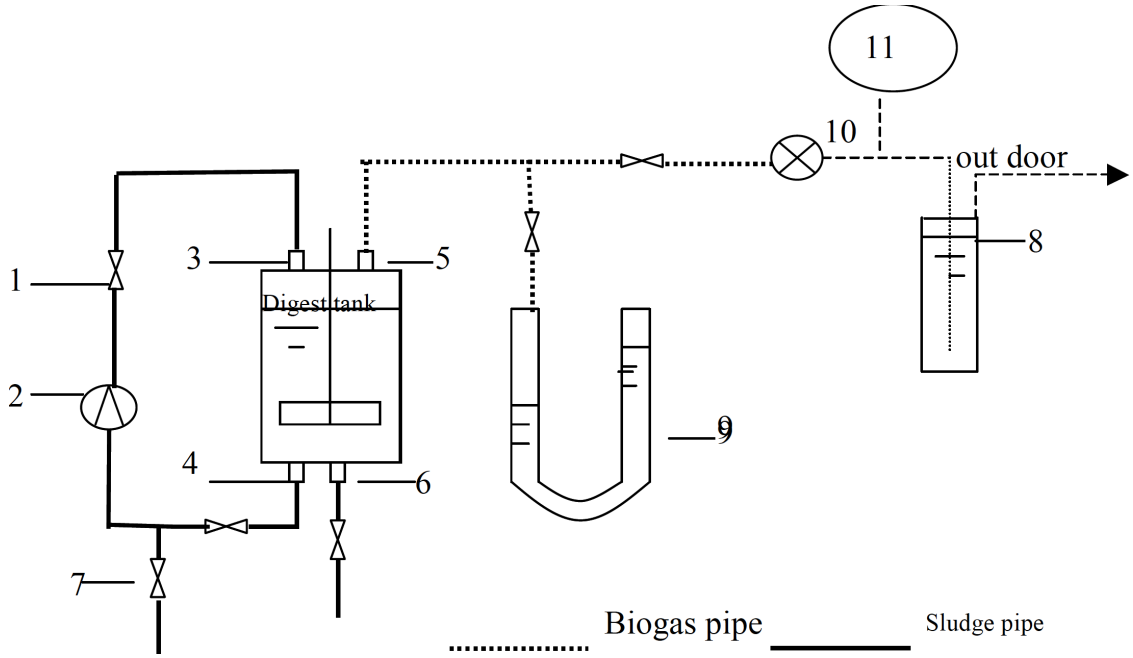
The total nitrogen content of the cutting gas is measured with the distillation method and the content of the organic carbon is measured by using the external heating method in the bichrome capacity method [4].

3. RESULTS AND ANALYSIS

3.1. C/N Ratio Change of Sludge After Grass Cuttings Are Added

Balance of the nutrition percent is a significant factor in the biological activity of the anaerobic microbe. C/N ratio of the sludge digestion is the significant nutritional factor affecting the sludge digestion system of the city wastewater system. If the C/N ratio is too high, the nitrogen content will be insufficient and the caching capability of the digestion liquid will be low. pH value is easy to reduce due to acidification and will affect the activity of the bacteria generating the methane. On the contrary, if C/N ratio is too low, the nitrogen content is too high which leads to formation and growth of the ammonia and nitrogen in the digestion liquid. Zhang Bo [5] and He Shijun [6] studied and proposed that the high-concentration ammonia nitrogen will suppress activity of the bacteria from generating methane. Lissens [7] studied and proposed that the best C/N ratio for the sludge anaerobic digestion is (15-20):1. When C/N ratio is less than 10:1, it will affect the digestion activity.

After detection, the content of the organic carbon is 22.36% in the raw sludge, the total nitrogen content is 2.93% and C/N ratio is 7.6:1, hence the C/N ratio is lower and affects activity of the anaerobic microbe and generally the sludge digestion efficiency of the sludge digestion tank of the city wastewater plant is low. Sosnowski [8] mixes 25% city's organic rubbish and 75% sludge of the wastewater



1 valve; 2 cycling pump; 3 sludge in; 4 sludge out; 5 gas out pipe; 6 Tube for Sludge Discharge; 7 sample valve; 8 washing can; 9 manometer; 10 flowmeter; 11 gas storage

Fig. (2). Equipment of anaerobic digestion.

plant, and as a result the C/N ratio increases from 9:1 to 14:1. The gas production rate is twice the rate of separate digestion of the sludge, so C/N ratio of the sludge digestion can be reasonably adjusted to effectively change the worse operation of the sludge anaerobic digestion system.

The content of the organic carbon of the grass cuttings is 41.26%, total nitrogen content is 1.41% and C/N ratio is about 29:1. The grass cuttings of greening with high carbon content are used to digest the sludge and improve nutrition balance of the sludge. C/N ratio is changed in accordance with Table **1**, after the grass cuttings are mixed with the biological sludge.

Table 1. The ratio of C/N after grass and sludge mixed.

Ratio of Grass Added (%)	0	10	20	30	40	50
Ratio of C/N	7.6	8.7	9.5	10.4	11.3	12.0

From the above table, with growth of the percent of the added grass cuttings, the C/N ratio in the mixed materials will gradually increase. When the percent of added grass cuttings is 50%, the C/N ratio will approach to 58% in the mixed materials and the C/N ratio of the sludge digestion will be improved remarkably.

3.2. Influence of Added Grass Cuttings on Gas Production Rate

After this experiment operates continuously for 2 months, the averages of daily gas production volumes are recorded. They are shown in Table **2**.

The Table **1** indicates:

(1) All digestion process parameters identified in the experiment refer to the actual operation control parameters of the digestion tank of Haihe wastewater plant. The experimental results indicate that the gas production rate of the digestion system is about 268L/kg.TS, when no grass cuttings are added. After the grass cuttings are added, the digestion system will remain stable and the gas production of the digestion system will increase with addition of the added grass cuttings. The maximum gas production can reach 8.78L/d. At this time, the gas production rate will increase to 348L/kg.TS and will increase by 80L/kg.TS compared to the rate without the added grass cuttings. The growth percent reaches 30%.

(2) If the increment of the gas production rate is solely caused by the grass cuttings, the gas production rate of the unit mass grass cuttings will increase

Table 2. The biogas production rate in different quantity of fresh grass d^{-1}.

Ratio of grass added (%)	0	10	20	30	40	50
Biogas yield/L·d	4.50	5.10	5.88	6.82	7.79	8.78
Increase of biogas production after grass added/L□d^{-1}	Loaded	0.60	1.38	2.32	3.29	4.28
Biogas production rate/L·kg^{-1}.TS	268	276	292	312	331	348
Biogas production rate by grass/L·kg^{-1}.TS		357	411	460	490	510

Table 3. Content of biogas in different ratio of grass added/%.

Ratio of Grass Added (%)	CH_4	CO_2	CnHm	CO	H_2	O_2	N_2
0	64.1	29.4	0.4	0.6	2.0	0.4	3.1
10%	63.8	30.1	0.3	0.5	1.8	0.3	3.2
20%	64.3	29.2	0.4	0.5	1.9	0.4	3.3
30%	62.9	31.1	0.2	0.4	2.1	0.1	3.2
40%	63.6	30.6	0.3	0.5	1.8	0.2	3.0
50%	64.5	29.4	0.3	0.5	2.1	0.1	3.1

remarkably with the addition of more grass cuttings. When the percent of the added grass cuttings is 50%, the gas production rate of each grass cuttings unit is 510 L/kg.TS. Compared to the value of 10% addition to grass cuttings, the gas production rate increases by about 43%. This indicates that the grass cuttings can effectively improve the performance of the anaerobic digestion of the city's sludge.

3.3. Influence of Added Grass Cuttings on Biogas Content

The contents of the biogas are detected for different addition percentages in the experiment, the results are shown as the Table **3**.

Table **3** indicates that the contents of the biogas will change irregularly for different percentages of the added grass cuttings. The methane content is kept between 62% and 65%, and CO_2 is kept at about 30%.

CONCLUSION

(1) The grass cuttings is added to the sludge digestion system of the city's wastewater plant as a complementary carbon source, which can significantly improve the nutritional structure, namely carbon and nitrogen ratio of the nutrition bacteria, and increase the gas production rate of the sludge digestion system, but it will affect contents of the biogas as well. When the dry weight of the added grass cuttings is 50% of the dry weight of the sludge, the gas production rate of the digestion system can reach 348L/kg.TS. Compared to the value without grass cuttings, the gas production rate will increase by 30%.

(2) The research indicates that the joint digestion processing of the grass cuttings for city greening and sludge of city's wastewater plant is feasible. This scheme not only utilizes the solid wastes for greening purposes, but also improves the digestion efficiency of the sludge of the city's wastewater plant and meets the idea of the recycling economy. The sludge digestion system is a relatively enclosed system in actual production, the biogas is flammable and explosive and includes highly toxic hepatic gas. The proposed sludge digestion system should be further discussed and studied to simplify the process and make it efficient and safe, so that the grass cuttings can be added into the sludge digestion tank and actual application performance can be improved.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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REFERENCES

[1] Fu, S.; Yan, X.; Fu, Y. Mesophilic anaerobic digestion of mixture of sludge from waste water plant and rubbish from kitchen. *J. Harbin Commercial Univ. (Nat. Sci. Ver.)*, **2007**, *23*(1), 32-35

[2] Cui, Y.; Chen, J. Current resource condition and prospect of kitchen rubbish. *Chin. Comp. Resour. Util.*, **2006**, *26*(10), 31-32.

[3] Jin, J.; Wang, S.; Xiao, X.; Yang, C. Experimental study on traditional anaerobic digestion process for food waste treatment. *Chin. Water Waste Water*, **2007**, *23*(15), 55-57

[4] Lao, J., Ed. *Soil Agricultural and Chemical Analysis Manual*. Agriculture Press: Beijing, **1988**, 233-644.

[5] Zhang, B.; Xu, J.; Cai, W. Suppressive influence of ammonia nitrogen in anaerobic digestion of organic waste. **2003**, *21*(3), 26-29.

[6] He, S.; Wang, J.; Zhao, X. Influence of ammonia nitrogen on activity of methane generated by anaerobic granule sludge. *J. Tsinghua Univ. Nat. Sci. Ver.*, **2005**, *2005*(9), 1294-1296

[7] Lissens, G.; Vandevivere, P.; De Baerel, L. Solid waste digestors:process performance and practice for municipal solid waste digestion. *Water Sci. Technol.*, **2001**, *44* (8), 91-102

[8] Sosnowski, P.; Wieczorek, A.; Ledakowicz, S. Anaerobic co-digestion of sewage sludge and organic fraction of municipal solid wastes. *Adv. Environ. Res.*, **2003**, *7*, 609-616.

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