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Co-digestion of Water Hyacinth *(Eichhornia crassipes)* mixed with Cow Manureto enhance Biogas Production

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Abstract : The objectives of the study was to determine composition ofwater hyacinth and cow manure, and pretreatment of water hyacinth effect on digestion to produce biogas.The batch experiment were carried out by mixed water hyacinth and cow manure with ratio 90:10; 70:30 and 50:50. Water hyacinth pretreatment prepared by heatingin 5% H_2SO_4 for 60 minute at 100°C. Experiment set for water hyacinth pretreatment and non pretreatment mixed with cow manure by using anaerobic digester. Research conducted for 30 days. The results of this study showed that pretreatment with a composition of 70:30% (w/w) water hyacinth and cow manure produced the highest volume of biogas as 395 mL, and without pretreatment with a composition of 70:30% (w/w) produced the highest volume of biogas as 438mL. The concentration of methane gas generated by pretreatment on the composition of 70:30% (w/w) is 15.56%and the highest points of methane gas produced without pretreatmenton the composition of 70:30% (w/w) is11.48%, which accieved on 30th day
Keywords : anaerobic, cow manure, digestion, pretreatment, water hyacinth.

Introduction

The growth of water hyacinth is influenced by the nutrients in a body of water, especially nitrogen, phosphate and potassium. Water hyacinth is able to reproduce two times faster asexually and may reach an half hectare within eight months[1]. The impact that can be caused by water hyacinth, among others: (1) decreaseslight penetration on water body,sooxygen concentration decreases, (2) reduce the aesthetic value of the aquatic environment, and (3) the water hyacinth that have died willcome down to the bottom of water body and cause sedimentation[2]. The rapid growth of water hyacinth can be overcome by using it as raw material for biogas production.

Anaerobic bacteria naturally degradedwater hyacinth into biogas through a long process, because it needs to break lignocellulose before the next process[3]. And thenorganic compounds are degraded into biogas through four processes: hydrolysis, acidogenesis, acetogenesis, and methanogenesis[4]. Pretreatmentby using dilute acid and high temperature can break the chain oflignocellulose to release cellulose, hemicellulose and lignin from its bond[5,6]. The temperature and duration of pretreatment has a significant role on both the amount of lignin removed from the biomass and the amount of digestible cellulose and hemi- cellulose that are retained[7]. Co-digestion of two or more types of organic materials is expected to overcome the disadvantages of a single material[4], such as material with low C/N ratio as Water hyacinth.Cow manure is potentially used as a mixture of water hyacinth in the biogas formation process, as it has a high enough of C/N ratio, abundantly and readily available. Mixing between Water Hyacinth and cow manure is expected to increase the value of C/N ratio to near the properly C/N ratio for anaerobic digestion process. The achievement of C/N ratio ranged between 25-30 is expected to establish optimum biogas produced[8,9]. However, recent studies have shown that composting can be carried out effectively at a lower C/N of 15[10]. The Objectives of this study were: (1)to determine the optimum composition of water hyacinth and cow manure to produce maximum volume of biogas, and (2)to compare the amount of gas produced in the reactor withpretreatment and without pretreatment.

Materials and Methods

Water hyacinth taken from watersource around Institut Teknologi Sepuluh Nopember (ITS)campus and cow manure that is used taken from the slaughterhouse of Pegirian Surabaya.The preparation of raw materials is done by separating the water hyacinth leaves and stems from the roots,and then washed andblended.Water hyacinth pretreatment is done by heatingin 5% H_2SO_4 for 60 minute at 100^oC. The purpose of pretreatment was to breakthe bonds of lignocellulose into hemicellulose, cellulose and lignin.After pretreatment, water hyacinth pH was neutralized by using NaOH until the pH becomes neutral. Hydrolysis stage can reduce the cellulose into glucose, and hemicellulose into glucose, galactose, mannose, xylose, and arabinose[11].

C-organic content, N-Total, and C/N ratio of raw materials are presented in Table 1.The experiments wasconducted by mixing water hyacinth and cow manure, pour into a reactor, and then diluted with water until it reached 5.5 L volume and total solid concentration 10%.Atotal mixture added was 770 gram wet weight.The ratio of water hyacinth to cow manure were 90:10; 70:30 and 50:50 (%w/w).

Measurement of gas production volume is done every day, for 30 days.Biogas volume measured by calculated increase water level in the manometer. The concentration of methane in the biogas was measured on days 15 and 30.Measurement of methane concentration in the biogas using Gas Chromatography (GC) Hewlett Packard (HP-series 6890).The variables used in this study were composition and pretreatment.

Results and Discussions

Raw materials characteristic

C-organic and N-total concentrasions have an effect on the process of biogas formation. Excessive C-organic concentration can decrease the production of the formed gas, and if the N-organic content is too high it can slow the work of microorganisms in the biogas formation process[11]. Table 1 shows the characteristics of raw materials, where water hyacinth has a high N content and cow manure has a high C content. Therefore, mixing of two materials produced a C/N ratio suitable for microorganism life, so the digestion process can work properly[12].

Table 1.Raw materials characteristic

Parameter	Water hyacinth	Cow manure
Water content (%)	90.3	87.5
Mass Density (mg/mL)	1.41	1.37
C organic (mg/L)	46.23	53.17
N Total (mg/L)	4.46	2.83
C/N ratio	10.6	18.79

Table 2 showed the content of hemicellulose andcellulose in water hyacinth, which can be utilized as a source of energy.It It will be broken down into polysaccharides. Polysaccharides are long polymers of sugar groups that need special treatment,to form reducing sugar. Reducing sugar utilized by microorganisms as a carbon source to form biogas.

Table 2 Water Hyacinth Content

Parameters	Content (%)[a]	Content (%)[b]	Content (%)[c]
Cellulose	34.2	27.0	23.31
Hemicellulose	27.0	20.3	22.11

Sources:[a] (13); [b](3); [c](14)

Pretreatment effect on the biogas production

Pretreatment intended to break lignocellulose, and then hydrolyzedhemicellulose and celluloce is known to increase the production of CH_4[3,5]. Somehow in this study, reactors with pretreatment produced the volume of biogas is lower than without pretreatment. Table 3 shownthe highest cumulative gas volume and methane levels of biogas generated by a mixture of water hyacinth and cow manure 70:30 (%w/w) without pretreatment (A_2C_1).The cumulative biogas volume produced at reactor A_2C_1 was 438.43 mL. The cumulative gas volume produced in the same mixture without pretreatment at reactor (A_2B_1)was 394.91mL.

Table 3. Cumulatif Volume of Biogas

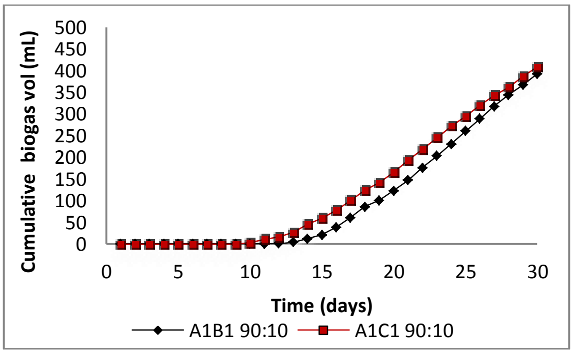
Treatment	Reactor	Composition	Volume (mL)
Pretreatment	A_1B_1	90:10	392.59
	A_2B_1	70:30	394.91
	A_3B_1	50:50	382.36
Non Ptertratment	A_1C_1	90:10	406.04
	A_2C_1	70:30	438.43
	A_3C_1	50:50	428.99

Decrease the volume of the biogas produced with pretreatment are influenced by specific ion in the substrate and toxic to microorganism.For examplea compound with excessive concentrations of ions, such as Na^+ and Ca^+> 8,000 mg/L. Meanwhile, Cu, Cr, Ni and Zn in low concentrations can be toxic to life anaerobic bacteria[15]. In the neutralization process, addition of NaOH required as much as ± 150.3g to each reactor. It means each liter contains 15,713.18mg of ion Na^+. The content of Na^+ greater than 8,000 mg/L,where this concentration could inhibit microorganisms growth.

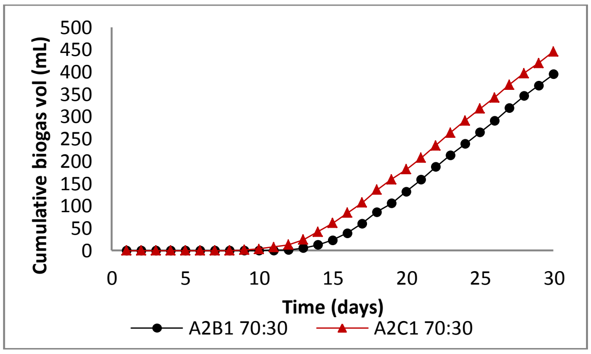
Glucoside bond hydrolysis resulting in dissolution of the cellulose in the initiation by the presence of water. Increased reducing sugar is expected to increase the produced gas. Advantages pretreatment method, and then hydrolysis are produced reducing sugar can be directly utilized by methanogenic bacteria. Methanogenic bacteria are added via cow manure to utilize reducing sugar.In this research, pretreatment has no effect on increasing the formation of biogas.

Raw materials composition effect on biogas production

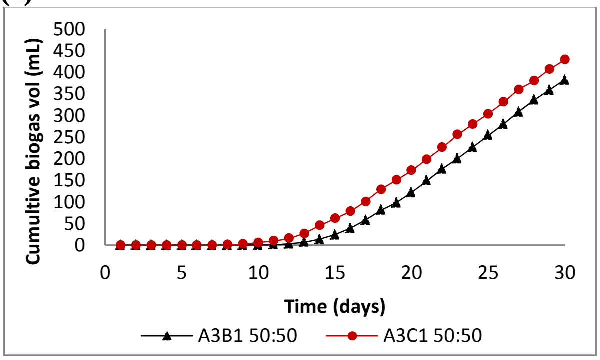
Reactor without pretreatment (A_2C_1) is generated the highest biogas production on composition of 70:30% (w/w), which produced 438 mL of biogas. This composition same to reactor with pretreatment (A_2B_1), which produced the highest biogas volume of 394.9 mL.The cumulative volume of biogas produced without treatment reactor (A_2C_1) is greater than 9.8% of the rector with pretreatment (A_2B_1). Fig. 1 shows the production of cumulative biogas generate by pretreatment smaller than without pretreatment for all composition.



(a)



(b)



(c)

Figure 1. Cumulative Biogas Volume: (a) Composition 90:10; (b)Composition 70:30; (c) Composition 50:50

At the beginning of the process until the fifteenth day, biogas has not been detected in reactors A_1B_1 and A_1C_1. Then from the fifteenth day biogas began to be produced until the end of the research on the thirtieth day. The rest of reactors produced biogas started on 9 days. This shows that the microorganisms in eachreactors are still in the acclimation stage. After biogas is formed, biogas production increases gradually and reached a stable condition at day 18of the reactors A_1B_1 and A_1C_1, and is stabled at day 16 on other reactors. At the end of the experiment, biogas is still formed although the volume has started to decrease slowly.Based on Figure 1 and Table 3, raw materials composition did not produce cumulative biogas volume differed significantly.

The concentration of methane in the biogas produced

Concentration of methane is an important factor in this study. Predicted in the pretreatment reactor produces the highest methane concentrations caused by reduction of the sugar content is more numerous in the pretreatment reactor. Hydrolysis can reduce levels of cellulose and increase levels of reducing sugars[3].Table 4 shows the concentration of the biogas produced.The quality of biogas is assessed from the methane content obtained. In this research reactor with pretreatment able to produce gas volume between 380-392 mL and the percentage of methane gas produced ranged between 15-18%. In the reactor without pretreatment treatment produced gas volume ranged between 400-438 mL and the percentage of methane gas of 10-17.5%.

Table 4. Gas concentrationin each composition

Treatment	Reactor	composition	Methane (%)	
			15 days	30 days
Pretreatment	A_1B_1	90:10	0.037	18.314
	A_2B_1	70:30	0.021	15.581
	A_3B_1	50:50	0.026	16.992
Non Pretreatment	A_1C_1	90:10	0.376	10.942
	A_2C_1	70:30	0.430	11.909
	A_3C_1	50:50	0.776	17.511

The highest concentration of biogas generated by pretreatment reactor ona composition of 90:10% (w/w) produced 18.3% of biogas (A_1B_1).The volume of gas produced in the biogas formation can not be a determinant of the quality of biogas concentration. Biogas concentration much influenced by pH and temperature[15]. This may be the case even though the 90:10 composition of the reactor A_1B_1 did not produce the largest biogas volume, but can result in the greatest methane concentration. Beside as described above, the addition of Na^+ to neutralize the pH may affect the performance of microorganisms.

Theoretically if the degradation of water hyacinth maximum, or the entire volatile organic components completely degraded into CH_4, and CO_2, usuallyCH_4concentration range 50-75% dan CO_2 concentration range 25-50%[16].The highest biogas volumeproduced in 30 days, whereas it only produced18.3%. Therefore, to obtain maximum results, the processing time required is more longer. To shorten the processing time can be engineered by adding appropriate microorganisms at the beginning of the process, so that microorganisms do not require acclimation time.

Conclusions

The highest cumulative gas volume and methane levels of biogas generated by a mixture of water hyacinth and cow manure 70:30 without pretreatment. The highest cumulative volume produced in the reactor A_2C_1amounted to 438.43 mL and methane percentage of 11,9%.Composition of raw material did not effect on biogas volume, but effect on methan concentration.

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