

DEGRADATION OF BIOWASTE LIQUID FRACTION IN ANAEROB BATCH REACTOR

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ABSTRACT

Biodegradable constituents of municipal solid wastes such as fruit and vegetable wastes are produced in large quantities in markets, and become a source of nuisance in municipal landfills or composting, because of their biodegradability. In order to resolve the problem and reduce the biodegradability of organic fraction municipal solid wastes, mechanical and biological treatment are applied. The aim of this research is to evaluate the biodegradation process of biowaste in liquid fraction made Caringin market in anaerobic batch reactor. Furthermore, the production of biogas from the reactor is also being monitored. Biowaste used in this research were taken from Caringin Market, Bandung. Mechanical treatment used include sorting, grinding and separating, while biological treatment used in this research was by anaerobic digestion using a batch reactor operated at a volume of 4 L. By mechanical treatment, the liquid fraction of the biowaste was obtained. This research used a substrate liquid fraction of the original biowaste, artificial, vegetables, fruits and variations of pretreatment sedimentation and without pretreatment. Physical-chemical parameters analyzed in this research are pH, VSS, volatile fatty acid (FVA), chemical oxygen demand (COD), ethanol, and biogas. The results show that the efficiency of COD removal at higher pretreatment sedimentation than without pretreatment. COD removal efficiency in substrate with pretreatment sedimentation 81.82% the biowaste original reactor, 72.73% the biowaste artificial reactor, 81.97% the vegetable reactor and 59.90% the fruit reactor. Methan produced 2.11% day-to-10 in the biowaste original reactor without pretreatment, and with pretreatment 0,16% the vegetable reactor and 0,019% the fruit reactor, which both occurred on the fourth day.

Keywords: anaerobic digestion, batch, biowaste.

INTRODUCTION

Waste problems in Indonesia until now has not get adequate attention. The studies on waste treatment is very little done, but more on aspects of management. Market waste contributor around 18.77% of municipal waste⁽¹⁾, and the problem of aesthetics, the environment and health, because it is concentrated in one place is massive. Waste

potentially be used as raw material for the formation of energy (biogas). The purpose of this study was to determine the degradation process biowaste fraction of the solid waste liquid and artificial original market and solid waste vegetables and fruits in anaerobic batch reactor.

METHOD

Sampling method which used in this research was grab sampling. Biowastes which used in this research were original biowastes, Fruit wastes, vegetable wastes, artificial biowastes from Caringin market. After collected, each biowaste goes to grinding process by SHREDDER FT0101-2HP type from normal size into small size (± 1 cm). The waste was stored at 4°C until it was used in the experiment. Any non-organic contamination was removed by hand before use.

After grinding process, the biowaste made slurry to reduce organic materials and nutrient in biowaste. Slurry undergo separation process by screening fabric to result liquid and solid fraction. These liquid fraction became a substrate for each reactor. The research used four anaerobic batch reactors with substrate sedimentation and without sedimentation before the input reactors. The substrate composition of liquid fraction is 100% original biowaste, 100% artificial biowaste, vegetable 75% : fruit 25% (vegetables reactor) and vegetables 25%: fruit75% (fruit reactor).

The substrates were inoculated with seeding from rumen, cow manure and sludge from anaerobic pond IPAL (Instalasi Pengolahan Air Limbah) which had been acclimated with the same kind of substrate used in experiment. The ratio of biowaste substrate and seeding is 9:1. This mixture was adjusted to reach neutral pH (7) before added to reactor.

Reactors used in this experimental were an anaerob batch reactor with operational volume 4 L, showed in Figure 1. At the reactor cover, there are silicon hose for gas sampling and substances addition, thermometer, and mixer. After the substrates and inoculum added to reator, it is covered and sealed. N₂ is flowed to remove oxygen in the reactor so that the anaerob condition was created.

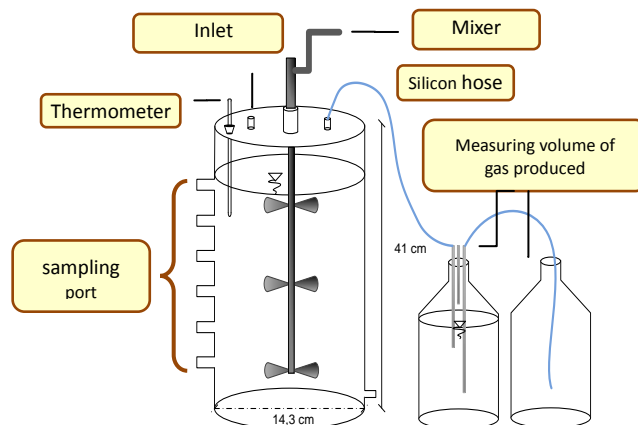


Figure 1. Reactor Scheme

Temperature, pH, VSS, total volatile acid (TVA), chemical oxygen demand (COD) and ethanol were determined according to Standar Methods for Waste and Wastewater Treatment ⁽⁶⁾. Biogas was analysed by gas chromatography.

RESULT AND DISCUSSION

The characteristic of substrate showed in Tabel 1 and 2. pH of original and artificial substrate is 4.7-5.45, whereas vegetables and fruits substrate are more acidic pH of 2.82-4.02. pH for each liquid fraction under neutral pH conditions, so that said liquid fraction to the original substrate, artificial, vegetables and fruits are acidic samples⁽⁷⁾. (Hammer and Hammer Jr. 2005).

Bicarbonate alkalinity in the range of 2500-5000 mg/l may function as buffer to handle the increased concentration of volatile acid that can decrease the pH⁽⁸⁾. Liquid fraction of the original biowaste alkalinity, artificial with pretreatment and without pretreatment, as well as for vegetable 1 is in the range of alkalinity so that they can function as a buffer against pH changes.

Anaerobic treatment is suitable for waste water with biodegradable COD of the medium range (around 2000 mg/l) to high (> 20,000 mg/l) ⁽⁹⁾. COD of liquid fraction of substrates in Table 1 and Table 2 has a value greater than 2000 mg/l, so that the liquid fraction can be treated with anaerobic system.

Table 1. Characteristic Substrate of Liquid Fraction Original and Artificial Biowaste

Parameter	Unit	Variation			
		Original 1	Original 2	Artificial 1	Artificial 2
pH	-	5.3	5.45	5	4.7
Alkalinity	mg/L CaCO ₃	2,606	3,016	2,503	2,786
Temperatur	° C	26	26	25	26
COD total	mg/L	9,164	8,592	12,888	11,456
VFA	mg/L acetat	3,267	1,653	4,967	1,397
Phosphat Total	mg/L	8.7	8.4	11.7	6.8
NTK	mg/L	9,051	7,230	9,427	6,697
TSS	mg/L	7,200	5,600	7,220	5,530
VSS	mg/L	5,893	4,875	5,683	3,540
Selulose	% w/w	0.79	0.52	0.78	0.67
Carbohidrat	% w/w	0.28	0.108	0.37	0.385
Lipid	% w/w	0.1878	0.1075	0.1976	0.1687

Note : 1-Without *Pre-treatment* sedimentation

2-With *Pre-treatment* sedimentation

Table 2. Charakteristic Substrate of Liquid Fraction from Vegetable and Fruit *Biowaste*

Parameter	Unit	Variation			
		(vegetables 75% : fruits 25%) or vegetables 1	(vegetables 75% : fruits 25%) or vegetables 2	(vegetables 25% : fruits 75%) or fruits 1	(vegetables 25% : fruits 75%) or fruits 2
pH	-	4.02	3.64	3.32	2.82
Alkalinity	mg/l CaCO ₃	4,602	5,137	7,705	7,384
VFA	mg/l Asetat	2,463	1,537	1,806	683
TSS	mg/l	4,940	728	4,370	636
VSS	mg/l	4,040	708	3,870	584
COD total	mg/l	28,800	13,017	33,600	17,898
Phosphat total	mg/l	64	36	44	45
NTK	mg/l	158	150	127	114
Carbohidrat	% w/w	0.1676	0.0798	0.4543	0.2397
Lipid	% w/w	0.2481	0.1945	0.2824	0.2471
Selulose	% w/w	0.60	0.60	0.76	0.66

Note: 1-Without *Pre-treatment* sedimentation

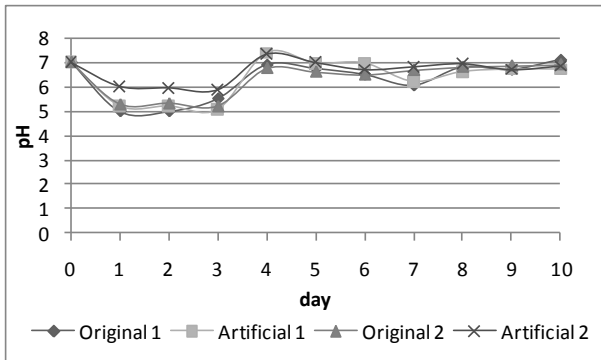
2-With *Pre-treatment* sedimentation

Cellulose is a biodegradable polymer but has a low level of solubility⁽¹⁰⁾. With the treatment of sedimentation, suspended particles will be removed including cellulose, whereas cellulose content in the liquid fraction was lower in the pretreatment sedimentation.

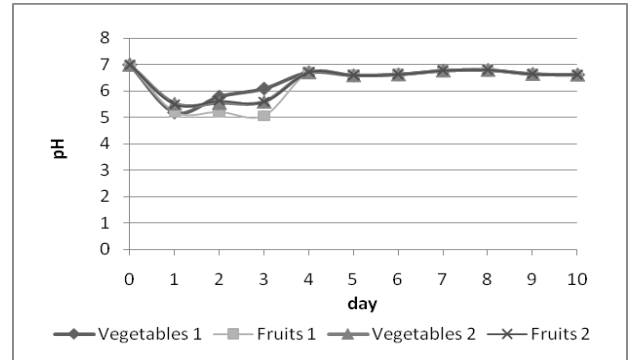
Carbohydrates are measured as the starch is a polysaccharide which degradable the monosaccharides, glucose and fructose⁽¹¹⁾. The highest carbohydrate content present in the fruit 1 (Tabel 2).

Environmental conditions of temperature and pH have an important effect on the survival and growth of microorganism in anaerob degradation organic matter. Bacteria will be active in specific pH range and show the maximum activities at optimum pH⁽²⁰⁾. The optimal pH required for asidogenic bacteria is between 5 and 6.5, while the optimal pH for methanogenesis is above 6.5⁽⁹⁾.

Based on this research, Figure 2 shows the pH profiles in all reactors. initial pH of all reactors around 7 but continued to decrease, then day-to-4 pH increased again and began to stabilize at pH 6.2 to 7.1 until the end of the research.



(a)

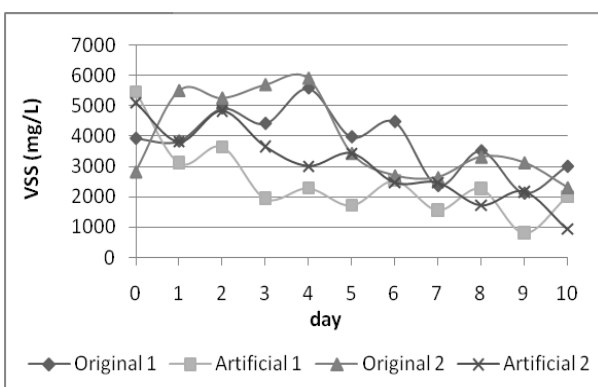


(b)

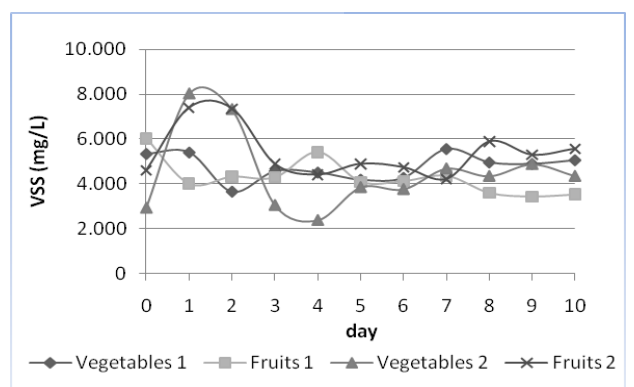
Figure 2. pH of *batch* reactor anaerob from substrate with *pretreatment* and without *pretreatment*. (a) Original and Artificial Biowaste, (b) Vegetables and Fruits Biowaste.

Decreasing pH indicate the accumulation of acids, due to high concentrations of volatile acids in a reactor. When bacteria asidogenik work, the more organic acids reproduced and cause a decline in pH⁽¹²⁾. With decreasing pH, which indicated all the reactors, suggesting asidogenesis process. After a day-to-4, the pH of the reactor began to stabilize. Increasing the pH value indicates the occurrence of phase decomposition asidogenesis toward methanogenesis.

Volatile suspended solids (VSS) shows the organic content of suspended solids, while also as the amount of biomass contained in reactor. The concentration of VSS is the number of active biomass and inert biomass contained in the reactor⁽¹³⁾. From the profile obtained through the VSS measurement results can be seen the growth of biomass in anaerobic batch reactor. **Figure 3** shows the profile of VSS in the liquid fraction by pretreatment and without pretreatment sedimentation.



(a)



(b)

Fig 3. VSS of reactor *batch* anaerob from substrate with *pretreatment* and without *pretreatment*. (a) Original and Artificial Biowaste, (b) Vegetables and Fruits Biowaste

Figure 3(a) shows the measurement results VSS, VSS tends to decrease during the research, original and artificial reactor VSS is 5570-820 mg/l. Figure 3(b), the reactor vegetables and fruit treated with pretreatment, the VSS increase until day 2 at 8000 mg/L and then decrease to 2000 mg/l until day 4, then tend to stabilize. As for the reactor without pretreatment of vegetables and fruits tend to be fixed from the start to the end of the research with VSS of 8029-2386 mg/l.

Soluble chemical oxygen demand (COD dissolved) is a value that indicates the need oxygen to oxidize dissolved organic compounds. In batch conditions where there is no influent or effluent in the system, and organic content measured as soluble COD continued to decrease⁽¹⁴⁾. Figure 4 shows profiles of dissolved COD in the reactor liquid fraction of original waste, artificial, vegetables and fruits with and without pretreatment sedimentation.

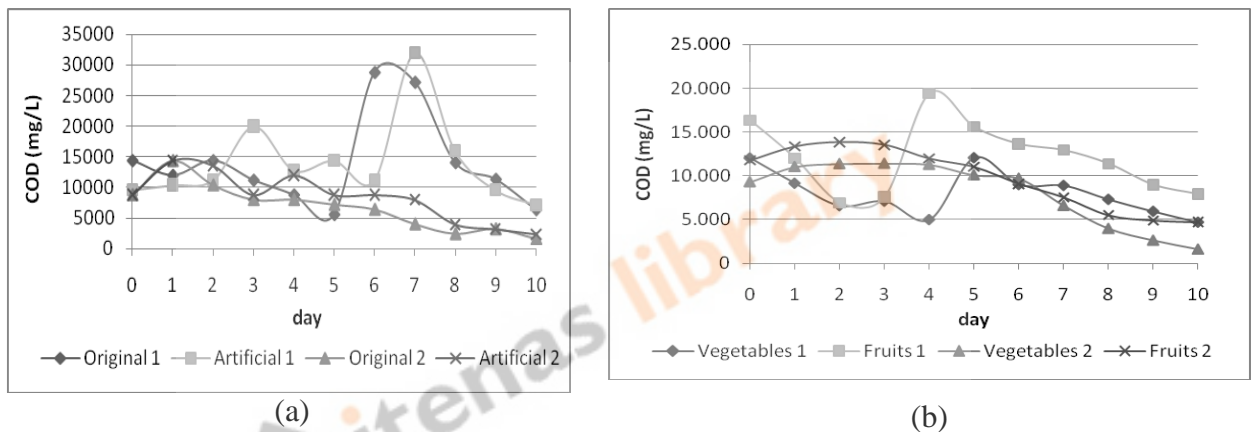


Figure 4. Concentration soluble COD in reactor batch anaerob from substrate with pretreatment and without pretreatment. (a) Original and Artificial Biowaste, (b) Vegetables and Fruits Biowaste

In Figure 4 shows the COD tends to decline in all reactors, but to original reactor 1, an artificial 1, fruit 1 and vegetable 1, an increase in concentration of about 1-2 days then decrease.

Soluble COD reduction associated with the activity of microorganisms in degrading organic content of the substrate into energy sources, such as methane CH_4 ⁽¹¹⁾. Things that affect the increase in soluble COD in anaerobic batch reactor is soluble microbial products (SMP). SMP produced by microorganisms into organic content so that the measured soluble COD increased⁽¹⁵⁾. In a review⁽¹⁶⁾, generally defined as compounds dissolved SMP contained in the effluent, but not found in the influent. SMP can be classified into two groups, namely utilization associated products (UAP) and biomass associated products (BAP), where UAP is a SMP associated with the use of the substrate and the growth of microorganisms, so the rate of its formation proportional to the rate of use of the substrate. BAP is a SMP associated with the decay of

