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KINETIC STUDY ON THE EFFECT OF WATER HYACINTHS IN FOODWASTE BIOGAS PRODUCTION

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ABSTRACT

Due to rapid growth of population and industrial globalization day to day energy demand increases and has an adverse effect on the fossil fuel depletion. This is the major problem accounted for the present and future economy. So in order to reduce our energy demands, there should be a need of distinguishing new concepts on renewable energy source because they are ecofriendly in nature. In the present paper, kinetics study on the effect of water hyacinths in food waste biogas production was carried out. The experiments consists of bio digester setup of 75litres capacity with 10% solid concentration at mesophilic temperature range of 35˚C and 20days retention times and by using modified Gompertz equation kinetics were determined for each bio digester. The kinetic parameters are Biogas yield potential (P), Maximum biogas production rate (Rm) and the Duration of lag phase (λ) were estimated for each bio digester. In the experiments cow manure is used as the inoculums and food waste is added daily .The results show that the mixture of water hyacinths and food waste will enhancing the biogas productions of about 1.2% when compared with food waste substrate alone.

Keywords: *Anaerobic Digestion (AD), Food waste (FW), Cow Manure (CM), Water Hyacinths (WH), Hydraulic Retention Time (HRT).*

1. INTRODUCTION

Energy –deficient age in which we live today demands that new and renewable sources of energy should be fully exploited. Renewable sources are considered as key energy carrier when the society is replacing fossil fuels with other alternatives [1]. Developing countries like India agriculture is main boon to set the economy of our country. There are varieties of feed stock available but there is lack in technologies in converting those waste into use full energy. By using renewable sources we can steps towards carbon neutrality [2]. Biogas is obtained by anaerobic decomposition. Anaerobic Decomposition is the breakdown of complex organic molecules into useful form of energy by microorganisms in absence of oxygen without affecting the nature [3]. The biogas generated from AD comprises of Methane (50-75%), Carbon dioxide (25-50%) and traces of H2S, H2, O2, and N2. The

process of Anaerobic Digestion are Hydrolysis, Acidogenesis, Acetogenesis, Methanogenesis [4]. The simple chemical process of overall reactions given by

$$C6H12O6 \rightarrow 3CH4 + 3CO2 (1)$$

Water hyacinths are having high potential of Biogas production because of rich in nitrogen, phosphorus and potassium content, so it can also be utilized as fertilizers[5].The present study focus on the use of water hyacinths with cow manureas inoculums in daily food waste biogas plants [6]. The experiments were studied in 75litres of bio digester with 10% solid concentrations and retention times of 20days. The data obtained from the experiments are used to check the fitness of modified Gompertz equations that describes the kinetic data of the anaerobic digestion process. The kinetic parameters are Biogas yield potential (P), Maximum biogas production rate (Rm) and the Duration of lag phase (λ) were estimated for each bio digester and compared [7].

2. MATERIALS AND METHODS

2.1. Feed stock collection

Water hyacinth used in this experiments was collected from Thamirabharani River at (Tirunelveli, Tamilnadu, India). Fresh cow manurewere used as the starter for the reactions and it is obtained from nearby cattle form and the food waste is feed to the digester daily so organic food waste is collected from our hostel canteen.

2.2. Experimental setup

The biomethanation unit consists of bio digester, gas holder guided by supporting pipe to collect the gas and water jackets is fill between the bio digester and gas holder in order to avoid escaping of biogas. The bio digesterhas a total capacity of 75 liters and 60 liters of working volume were used in all the experiments. Biogas produced from the digester can be measured daily by means of height of gas holder rise. The experiments was done at the normal environmental conditions about 35˚Cmesophilic temperature so that there is no need of water bath arrangements.

2.3. Sample Analysis

Solid analysis: Total solids and volatile solids were analyzed for water hyacinths and cow dung according to the standard methods.

pH analysis: pH was measured by pH meter which consists of potentiometer, a glass electrode, reference electrode and temperature compensating device. Electrodes were connected to the pH meter and were calibrated using buffer solutions before pH analysis [8].

2.3. Preparation of Fermentation Slurries

Biomethanation of WH, CM were studied in series of experiments about total 75litres of capacity with working volume of 60litreswith 10% solid concentrations and retention times of 20days. In both the experiments FW is added daily. In the present study cow manure is used as inoculums to start the reactions so they are mixed with water and remain undisturbed

for more than 14days. Fresh water hyacinths collected from the river are chopped into small sizes up to 2cm.The respective table shows the contents of the digester.

Table1.Contents of Digester

Digester	**CM**	**Water**	**WH**	**FW**
Digester 1	10kg	10kg	---------	0.500kg
Digester 2	5kg	50kg	5kg	0.250kg

2.4. Modified Gompertz Equations

The kinetic data of WH with FW and CM with FW were checked for the fitness of modified Gompertz equation. The modified Gompertz equation gives data of cumulative biogas production, function of bacteria growth and period taken by the microbes to digest the substrate. The modified Gompertz equations is given by

$$P = A\exp\left\{-\exp\left[\frac{Ue}{A}(\lambda - t)+1\right]\right\}$$

Where, P- Cumulative biogas production, L (g VS) $^{-1}$ at any time t

A- Biogas yield potential, L (g VS) $^{-1}$

U- Maximum biogas production rate, L (g VS) $^{-1}$d^{-1}

λ- Duration of lag phase, d (days)

t -Time at which cumulative methane production P is calculated, d

e- exp (1)=2.718

The parameters P, Rm and λ were estimated for each of the digester using POLYMATH software [9].

3. RESULTS and DISCUSSIONS

3.1. Solids and pH analysis

Total solids (TS) were determined at temperature of 105˚C by drying the samples in oven over night and volatile solids (VS) were determined using loss of weight between ignited samples and ash free dry weight kept at temperature of 550˚C for 2 hours [8].

Table 2. Solid analysis and pH data

Materials	**%TS**	**%VS**	**pH**
Cow Manure	20.12	74.86	6.2
Water Hyacinths	17.26	83.15	6.5

3.2. Kinetics of biogas productions

The cumulative biogas productions of each digester were experimentally taken with respective time (days).

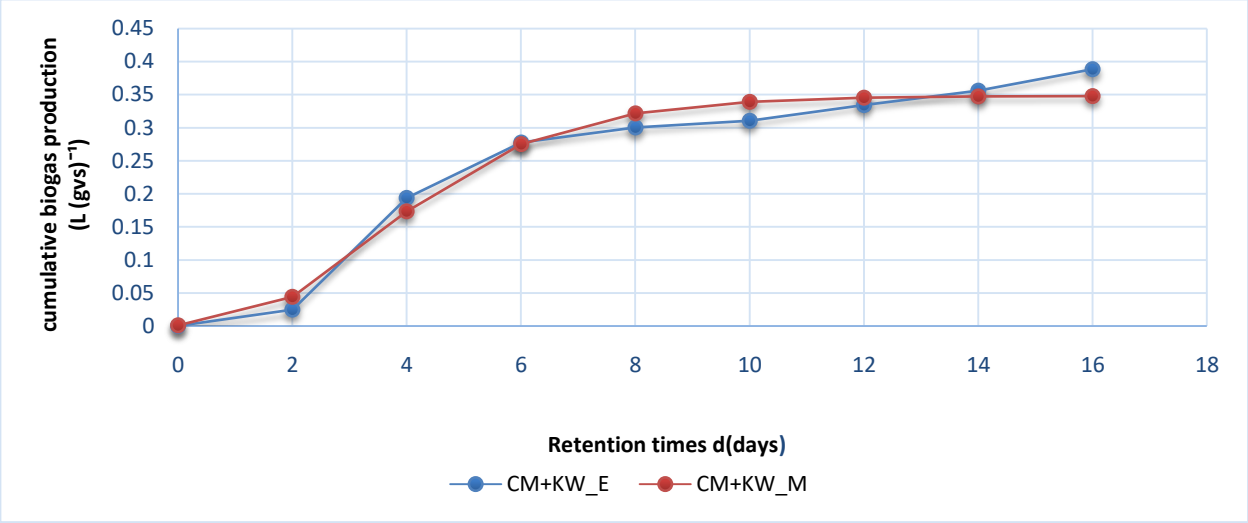
Table 3. Cumulative Biogas production data

Cumulative biogas production(L (g VS) $^{-1}$)		
Digester →	CM+FW	WH+FW
Time ↓(days)		
0	0	0
2	0.0246	0.030
4	0.1934	0.1083
6	0.2772	0.1966
8	0.3000	0.2555
10	0.3104	0.3484
12	0.3343	0.3818
14	0.3558	0.4332
16	0.3882	0.4572

The data obtained from the experiments are check for the fitness in modified Gompertz equation to quantify the analytical parameters of Biogas yield potential (P), Maximum biogas production rate (Rm) and the Duration of lag phase (λ) of each digester. The parameters obtained are listed in table 4.

Table 4. Summary Performance of Bio digesters

Digester	Biogas yield (L (g VS) $^{-1}$)	Modified Gompertz parameters			R^2
		A, (L(gVS) $^{-1}$)	U,(L(gVS) $^{-1}$d $^{-1}$)	λ , d	
CM+FW	0.3882	0.3481	0.02001	2.501	0.9757
WH+FW	0.4572	0.4984	0.08713	6.726	0.9969



From the observations from the table 4 the bio digesters of CM+KW and WH+KW had the shorter lag phase of 2.501days and 6.726 days respectively. This clearly indicates that WH required more retention times to digest [10]. The bio digesters of WH+KW exhibits higher biogas productions rate (0.08713 L (gVS) $^{-1}$d^{-1}) than CM+KW (0.02001L (gVS) $^{-1}$d^{-1}). Therefore the amount of gas produced at the end of digestion period was highest for the bio digester of WH+KW (0.4572L (g VS) $^{-1}$).The WH can mixed with CM as inoculums will enhance the biogas productions because of enriched inoculums to improve anaerobic digestions [11].

4. CONCLUSION

The following conclusions can be drawn from the study presented in this paper:

- Kinetics was studied for the WH and CM in FW biogas plants. The most important results is mixture of WH and CM digester produce more biogas and the slurry are rich in nitrogen and potassium content so it can be used as fertilizers.
- WH have high capacity of biogas productions but requires suitable inoculums to enhance the biogas yield.
- In modified Gompertz equations the cumulative biogas production is the function of retention times.

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