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Study of Biogas Production from Bagasse and Filter Cake



Abstract: - Bagasse, an abundantly available crop residue has a high potential that remains unutilized or burnt as fuel. The complex structure of bagasse poses recalcitrance to its sustainable utilization through anaerobic digestion. So, to enhance biogas production 2% NaOH pretreatment of bagasse and filter cake were carried out in this study at ambient temperature for a day. Biogas production was observed for 35 days of retention period at mesophilic temperature in batch process mode. Proximate analysis and analytical techniques such as Fourier Transform Infra-Red (FTIR) were used to characterize the residues and observe the effect on chemical structures of pretreated bagasse and filter cake respectively. Raw Filter Cake was found to produce the highest biogas production.

Keywords: *Anaerobic digestion, Biogas, Bagasse, Filter Cake, Pretreatment*

I. INTRODUCTION

The overall development of a country depends upon its per capita energy consumption. Thus, energy plays a crucial role in the socio-economic development of a country. As the population increases with time it will exert pressure on the energy and agriculture sectors [1]. In this scenario, the biomass obtained after harvesting different crops such as corn stalks, bagasse, rice straw, and wheat straw will also increase proportionately in nature, which can be efficiently used as a renewable source of energy [2]. Biomass refers to the organic matter generated from the plants by the photosynthesis process. It involves the utilization of atmospheric carbon dioxide and water by the plants for the production of carbohydrates formation which further form biomass. The solar energy required for this process is stored in the structural components of the biomass's chemical bond. The organic matter contains 80% polysaccharides which are a good source of energy [3]. It is accounted as the third largest source of energy after coal and oil across the globe and can be converted economically into biofuels [4]. Converting biomass into bioenergy can result in reducing greenhouse gas emissions by 86% and help in preventing various undesirable changes in the environment [5]. Sustainable utilization of crop residue through the biochemical process of anaerobic digestion can help to provide alternative clean and green energy as biogas [6]. Biogas primarily consists of methane, carbon dioxide with small amounts of hydrogen, and hydrogen sulfide (H₂S), Biomethane has the potential to substitute natural gas for chemical production [7].

India is the second largest producer of sugarcane after Brazil with about 21% of agricultural land used for sugarcane. Byproducts of the sugar industry such as bagasse, molasse, and filter cake are frequently available biomass for energy production. However, the lignocellulosic nature of bagasse provides hindrance to its utilization through anaerobic digestion. Pretreatment of bagasse is essential for its sustainable utilization through anaerobic digestion [8]. Physical pretreatment followed by chemical or biological pretreatment was found to be efficient as reported by various researchers in their study [9][10]. Kivaisi and Eliapenda, 1994 observed that HCl pretreatment of bagasse and coconut fiber resulted in 32% and 76% enhancement in methane production respectively from these biomasses [11]. Another study reported that pretreatment of corn stover with 1%, 2.5%, 5%, and 7.5% sodium hydroxide for 24 hours increased the biogas yield by 37% from untreated biomass with 5% NaOH pretreatment [12]. 4% (w/w) NaOH pretreatment of bagasse at ambient room temperature for a day resulted in maximum biogas production as compared to 6% (w/w) NaOH pretreatment of bagasse at the same temperature [13]. So, the chemical pretreatment method was found to be effective in the enhancement of biogas production. Accordingly, the present work was done to analyze the effect of 2% (w/w) NaOH pretreatment on bagasse and raw filter cake.

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II. MATERIALS & METHODS

Sugarcane bagasse and filter cake used in the present study were collected from a Sugar Mill, in Naraingarh, Ambala, Haryana, India. The cow dung required for co-digestion was collected from a cattle shed in Ambala, Haryana. Bagasse was physically pretreated through a grinding machine to reduce its particle size. After that, bagasse and filter cake were kept soaked in 2% (w/w) NaOH solution at room temperature for 24 hours, and sun-dried to make it moisture-free. The slurry was prepared by mixing bagasse with cow dung in a ratio of 1:2 and with water in a ratio of 1:3. Similarly, the slurry was prepared using filter cake, cow dung, and water. After that four one-litre digesters were fed with raw filter cake, untreated bagasse, 2% NaOH pretreated filter cake, and 2% pretreated bagasse. The biogas was measured using the water displacement method. FTIR (Fourier Transform InfraRed) was used to analyze the effect on chemical bonding of lignocellulose.

III. RESULTS & DISCUSSION

A. Proximate Analysis

Waste-derived fuel characterization can be carried out by performing the proximate analysis of waste. Moisture content, ash, volatile matter, and total solid content present in biomass play a critical role in evaluating the fuel characteristics. As moisture adds weight to biomass without increasing its heating value and the evaporation of water, reduces the heat released from the fuel. Ash adds to the weight without releasing any heat during combustion. Table 1 shows the result of the proximate analysis of untreated and pretreated bagasse and filter cake. the total solid and volatile solids present in raw filter cake range between 79% to 86% whereas in bagasse it ranges between 72% to 84% as can be seen from Table 1.

Table 1. Proximate analysis

Analysis (%)	Raw Bagasse	Raw Filter Cake	Pretreated Bagasse	Pretreated Filter Cake
Moisture content	15.33	13.6	17.7	12.72
Total solid	84.6	86.4	82.3	87.28
Volatile Matter	72.6	79.08	71.46	79.2
Ash Content (%)	2.66	6.4	2.6	7.44

B. Effect of Chemical Pretreatment on Structure

Fig. 1 shows the FTIR spectrum of untreated bagasse, and the peak at 3394.14 cm⁻¹ indicates the hydroxyl group presence among the hemicelluloses and cellulose groups, which act as the backbone of the carbohydrates. The band at 2914 cm⁻¹ contributes to the stretching of the C-H bonds present. The band at 1633.97 cm⁻¹ represents the presence of C=C bonds. The peak at 1038.54 cm⁻¹ shows us that C-O stretching is also present in it which indicates the presence of primary alcohol in it whereas the presence of a sharp peak at 795.93 cm⁻¹ indicates the presence of C=H stretching [14]. Similarly, the Peak at 3319.26 cm⁻¹ in the FTIR spectrum of filter cake was also observed representing the presence of the O-H group i.e. hydroxyl group, whereas the presence of alkane is confirmed by the peak at 2914.35 cm⁻¹. The alkene group is also present in the sample as the peak also comes out to be at 1636.63 cm⁻¹. Also, the presence of an acidic group is confirmed by the peak at 1028.77 cm⁻¹ [15]. Moreover, the peak at 738.83 indicates the presence of an alkene group.

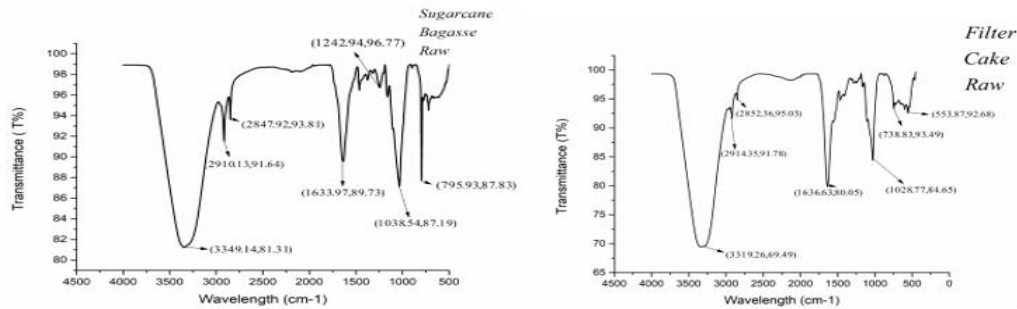


Fig.1 FTIR Spectra of untreated bagasse and filter cake

The wideband between 3300 cm⁻¹ and 3450 cm⁻¹ attributes the hydroxyl group present in cellulose and hemicellulose as can be seen from fig.2. The band at 2918.12 cm⁻¹ is attributed to the stretching of C-H bonds present as methyl and methylene of cellulose. The strong peak at 1641.96 cm⁻¹ indicates the presence of the amino group. Also, the peak at 1023.43 cm⁻¹ is attributed to the presence of an amine group in the sample whereas the intermolecular changes observed at band 803.93 cm⁻¹ are attributed to the characteristics of β-1, 4-glycosidic bond linkages present in cellulose and cleavage of intermolecular hydrogen bonds. FTIR spectra of pretreated filter cake represent that the band at 3278.93 cm⁻¹ indicates the presence of O-H (hydroxyl group) and the band at 2918.12 cm⁻¹ indicates the presence of the aldehydic group as can be seen from Fig. 2. The peak at 1633.97 cm⁻¹ is attributed to the amino group. The aromatic ring character is also attributed to the peak at 1407.35 cm⁻¹ [16]. And the aliphatic amine is confirmed by the presence of a very sharp peak at 1031.43 cm⁻¹.

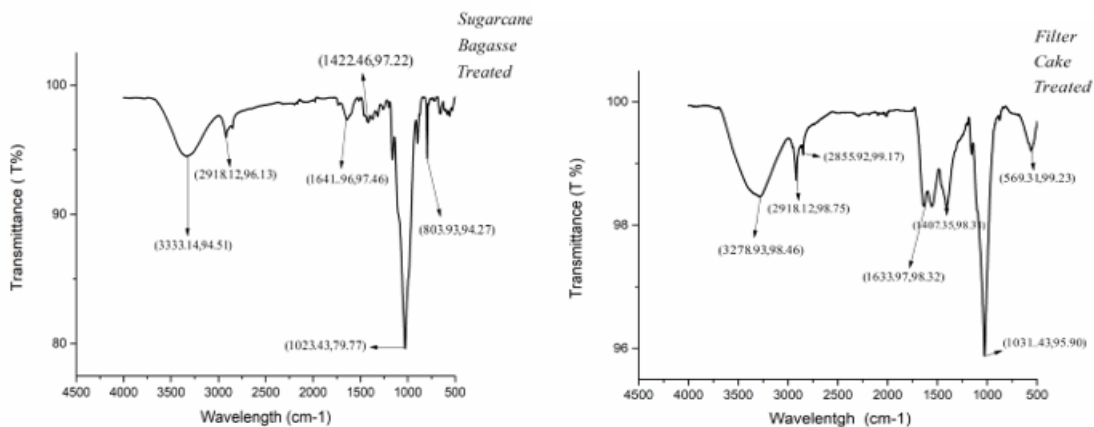


Fig.2 FTIR Spectra of 2% NaOH pretreated bagasse and filter Cake

C. Measurement of Biogas Production

The biodegradation of biomass through anaerobic digestion is a slow process. During the initial five days, a small quantity of biogas production was observed from raw and pretreated bagasse respectively. However maximum biogas production was observed between HRT of 10 to 25 days. After the 25th day, the biogas production was found to be at 20 cm³ whereas, in pretreated bagasse, the point was found to be at 30 cm³ as seen in Fig.3. A Similar trend was seen in raw and treated filter cake respectively as seen in Fig.3. After 25 days, a near saturation point came in both cases, where the volume of gas was still found to be higher in the case of raw filter cake whereas, in the case of treated filter cake, it was found to be very less:

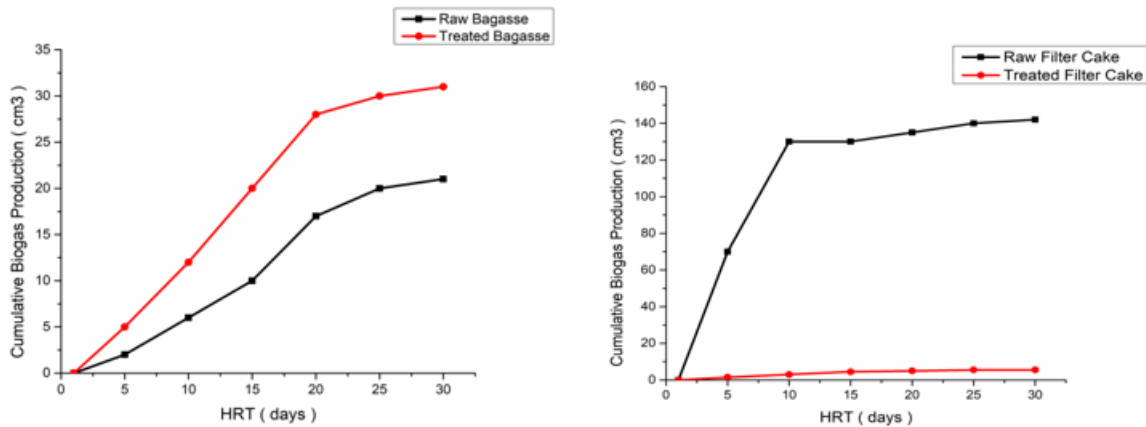


Fig.3 Biogas production for HRT of 35 days

The NaOH pretreatment was found to be effective in the enhancement of biogas production from bagasse. However, NaOH pretreatment adversely affected the filter cake as seen from the results obtained from an experimental study of biogas production

IV. CONCLUSION

Bagasse and filter cake were found to have sufficient solids to get converted into energy. Pretreatment of biomass with 2% NaOH was found to be effective in disruption of lignin-cellulose-hemicellulose bonding. However, maximum biogas production was found to take place from raw filter cake as compared with pretreated bagasse and pretreated filter cake.

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