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Agricultural Dry Residues Management Stretegies and its Potential for Biogas Production

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Abstract
Anaerobic digestion reactions can be used to produce biogas from sources of agricultural waste. The ecology has been harmed by fossil fuels, while biogas solves environmental and climate change-related problems. The goals of biorefineries, global warming, nutrient recycling, and greenhouse gas reduction come after the techno-economic study of biogas production. Furthermore, various metabolic reactions, the use of various microbes, filtration, upgrading, and CO2 removal from the gas mixture procedures all play a role in the creation of biogas. Agricultural wastes are important sources for the production of biogas. Biogas or bio methane generation relieves the negative impact of fossil fuels and agro wastes. Biogas can be generated from agro-industrial wastes with lignin, cellulose and hemicellulose. An very promising method for handling agricultural waste that reduces pollution and produces energy effectively is anaerobic digestion. Therefore present study was conducted for screening of bio-waste for biogas generation. Resultants in all three digesters gas generation was found in sorghum than wheat straw while coconut shows the least gas generation. Study also found that higher gas production was seen at 21 DAD (day after digestion). The study concluded that agricultural wastes are important sources for the production of biogas. Therefore selection of most cellulosic agricultural plants will be helpful for biogas production and also relieve the negative impact of fossil fuels and agro wastes.

Keywords: Agricultural Waste, Cellulosic Materials, Biogas Production

Introduction

Systems for supplying sustainable energy, which prioritize using renewable natural resources to meet energy demand, must advance. Interest in biogas as a substitute renewable energy source has grown due to the growing usage of fossil fuels and environmental worries about greenhouse gas emissions and climate change [1]. To overcome the greenhouse gas (GHG) emission by utilizing renewable energy production is of rising significance. One method for using agricultural biomass as a sustainable source of renewable energy is the creation of biogas. Biogas was made from a variety of energy crops combined with organic waste and animal manures. According to Thiruselvi et al., biogas has demonstrated considerable promise as a sustainable energy source for both home and industrial purposes, and as a cost-effective way to address the world's energy dilemma [2].

Anaerobic digestion of biomass wastes, such as animal dung, plant residues, waste waters, municipal solid wastes, human and ago-industrial wastes, etc., produces biogas, which is environmentally benign. Methane and carbon dioxide make up the majority of the biogas, with trace amounts of other gases such as carbon monoxide, hydrogen sulphide, ammonia, hydrogen, nitrogen, oxygen, and water vapor. The breakdown of organic matter or substrate results in a number of biochemical changes that define the anaerobic digestion process. The entire process is divided into multiple phases, including hydrolysis, the acid-forming phases of acetogenesis and acidogenesis, and methanogenesis at the end.

The production of biogas from the breakdown of organic matter also depends on the intricate interactions between a variety of bacterial species, the two primary categories of which are methanogens (which make methane) and acidogens (which produce acid) [3]. Biogas has widely used for cooking, lighting and heating in houses while in industry used as combined heat and power generation, used as fuel for transportation purpose when biogas converted to biomethane. Biomass which rich in content of carbohydrates, proteins, fats, cellulose and hemicellulose are mostly used as feedstocks for the production of biogas [4]. Carbohydrates and proteins show rapid conversion rates than fats and gives more biogas yield. To produce biogas, developed countries now utilizing the organic waste which produced and generated in municipal, industrial and agricultural processes in high amount.

In order to promote renewable alternatives, bioenergy might be a key component. Given its quantity and qualities that make it renewable, widely deployable, and nearly GHG-neutral, bioenergy is really thought to be the fourth greatest energy resource in the world. According to Bilgen and Sarıkaya, the primary categories for use are forestry resources, agricultural resources, sewage and industrial organic wastewater, municipal solid wastes, animal and poultry manure, and biogas [5]. If agricultural wastes are managed sustainably, many of them may be considered valuable resources. The base of raw materials is varied and includes trash from farms and animal husbandry as well as stalks, straw, leaves, roots, husks, and seed shells. These biomass sources have a wide range of different qualities. The main distinction is between residues that are mostly dry, like straw, and are better suited for thermo-chemical conversion processes, like gasification, combustion, and pyrolysis, and residues that are wet, like animal slurries, and are better suited for biological conversion processes, like biogas production. The substrates and technology that will work best for producing biogas will be the main topics of this research. An outline of the gas yields obtained from various tropical substrates following approximately demonstrates the potential of waste management in this paper. The primary sources of agricultural waste and the primary raw materials for the fermentation of biogas are crop straw and livestock manure. Agro-industrial wastes including lignin, cellulose, and hemicellulose can be converted into biogas. Agro wastes produce a significant amount of biogas (>94%) [6]. Therefore, this study conducted for assessment of capable biogas production agricultural waste. Study hypotheses that the potential of agricultural waste for biogas production. Presented study also identified that bio waste management technique. Therefore, this study will be helpful for biogas production and also waste management technique with respect to sustainable ways.

Materials and Methods

Selection of Agricultural Waste

Locally available agronomic crops having high gas production potential due to their high content of cellulose, hemicellulose and lignin. The select Sorghum, Wheat straw and Coconut leaves as agricultural waste for the biogas production which are easily available. The sorghum, wheat dried crop residues and coconut leaves was collected from the village Pimpli gaon, Baramati, Dist. Pune. Which 5 km away from Baramati on Baramati-Indapur road. Animal manure such as cow dung for cultural use was collected from nearest dairy farm and sewage sludge was collected from the Baner Sewage Treatment Plant which is under the Pune Municipal Corporation at Aundh.

Pre-Treatment to Agricultural Waste

The substrate's solids are improved by the mechanical pre-treatment size reduction, which breaks down and increases micro-organisms' access to the biodegradable components. Because the size reduction approach breaks large structures into shorter chains, it improves the speed and efficiency of hydrolysis by making residue particles more accessible to microorganisms. To reduce the size of crop residue firstly, chopped the crop residues in 3 to 4 cm in size. This chopped residue was going under the operation of grinding in mixer to get in form of smaller size or fine powder of selected agricultural crop waste. Lignocellulosic substrate, which is in smaller size or in powder form was pre-treated by soaking sorghum, wheat and coconut waste in water at room temperature for 24 hrs (B. Jankovicova 2023). For the softening of biomass and nutrient availability for the micro-organisms in anaerobic digestion process. Here we take 100 gm crop residue powder in 500 ml of water.

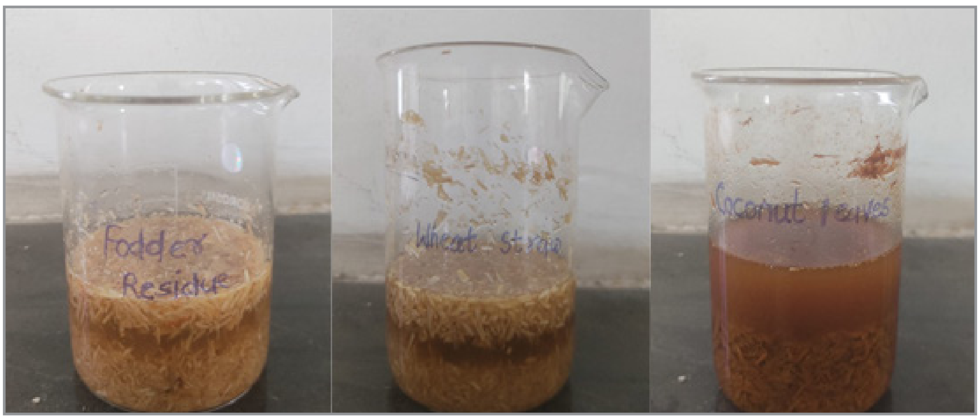


Figure 1: Soaking of different agricultural crop waste in warm water

Design Anaerobic Digester and Experimental Set Up

To design an anaerobic digester, use 2000 ml capacity filtrate flask with glass tabulation. At the upper side of filtrate flask there is a glass tabulation which is the port for gas collection. In lab, set a 2000ml capacity filtrate flask as Bio-digester, which having a one port at the upper side of flask for the gas collection and that is connected with pipe for generated gas transportation. Here the use of magnetic stirrer for the mixing and homogenization in that magnet stud is act as agitator. The collected gas was measured with the help of gas syringe of 10ml volume.

Preparation of Slurry

For the slurry preparation here, we take 500ml soaked sample of crop waste in which 100gm grinded crop residues taken in 500ml warm water with 250ml cowdung slurry (50gm in 250ml tap water) and 500ml sewage sludge and add some tap water to level the 1500ml volume.

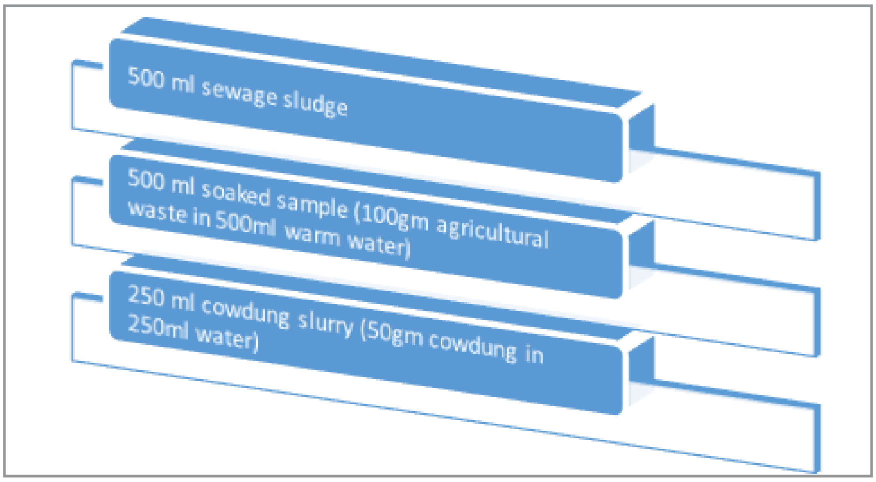


Figure 2: Experimental set-up for Biogas Production

Analysis of Biogas

Portable Gas Analyser is used for the analysis of biogas which is generated from the anaerobic digesters. The portable gas analyser gives the composition of biogas that produced in the anaerobic digesters. Presented study conducted for potential applicability of agricultural waste for biogas production. Result of the study showed that various type of agricultural waste and its biogas production rate. The study also confirms that the composition of various gases in selected agricultural waste.

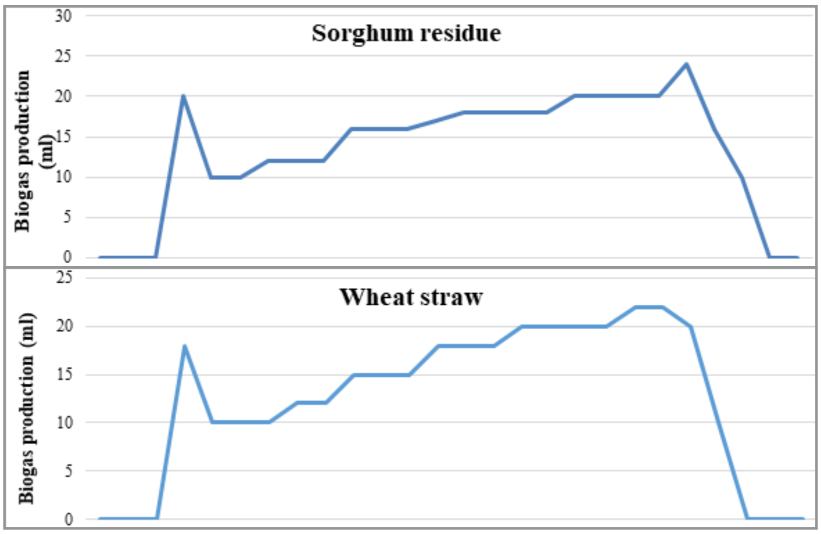
Results and Discussion

Bio-Digester

The production of the biogas from the agricultural crop residues waste of sorghum, wheat straw and coconut dried leaves were carried out by anaerobic digestion in which cow dung as culture and sewage sludge as nutrient source. That results total generation of biogas was seen 343ml, 325ml and 252ml respectably in the digester sorghum, wheat straws and coconut leaves (Table 1). A study was also reported that higher gas production was seen in crops. Resultants higher production of gas was seed in sorghum (343ml) at 24 DAT while coconut leave showed least gas production (252ml). Various study was used for biogas production from agricultural waste [7]. The research described here demonstrated that the main ways in which anaerobic digestion of slurry containing bio-waste, crop residues, and crops decreased GHG emissions were by reducing CH4 emissions during post-digestive storage and by replacing fossil fuel for power and heat production. When comparing biogas energy systems to fossil fuel energy systems, the primary environmental advantages were lower greenhouse gas emissions and resource use [8]. In this regard, the use of animal manure for biogas production is significant because it can be used to offset avoided emissions from the conventional manure management reference system. This is not the case for energy crops and straw, which would not be sources of greenhouse gases in a scenario without AD [9].

Table 1: Gas production rate observation at daily based from selected agricultural waste in different digester

Observation no.	Date	Gas collection data in ml		
		Sorghum crop residue	Wheat straw	Coconut leaves
1	09/03/2024	00	00	00
2	10/03/2024	00	00	00
3	11/03/2024	00	00	00
4	12/03/2024	20	18	00
5	13/03/2024	10	10	14
6	14/03/2024	10	10	07
7	15/03/2024	12	10	07
8	16/03/2024	12	12	09
9	17/03/2024	12	12	09
10	18/03/2024	16	15	12
11	19/03/2024	16	15	12
12	20/03/2024	16	15	12
13	21/03/2024	17	18	13
14	22/03/2024	18	18	14
15	23/03/2024	18	18	15
16	24/03/2024	18	20	15
17	25/03/2024	18	20	16
18	26/03/2024	20	20	19
19	27/03/2024	20	20	18
20	28/03/2024	20	22	20
21	29/03/2024	20	22	20
22	30/03/2024	24	20	12
23	31/03/2024	16	10	08
24	01/04/2024	10	00	00
25	02/04/2024	00	00	00
26	03/04/2024	00	00	00
	TOTAL	**343**	**325**	**252**



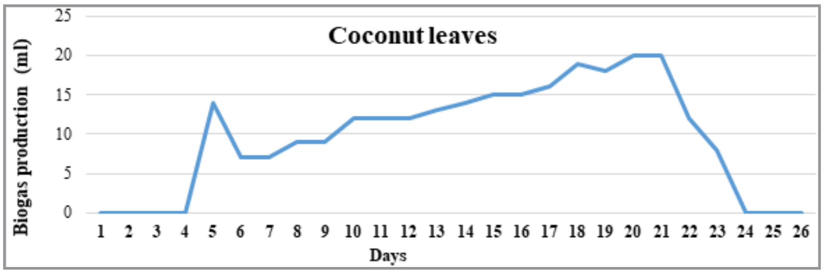


Figure 3: Gas production rate observation at daily based from selected agricultural waste in different digester.

Analysis of Generated Gas

Biogas predominantly contains methane and carbon dioxide, with methane being the main energy source. Alongside these, it may contain small amounts of nitrogen and oxygen (0–10%v), as well as traces of sulfur compounds (such as H2S), silicon compounds (like siloxanes), ammonia, halogenated compounds, and other volatile organic compounds (VOCs) at levels measured in parts per billion to million. Biogas is typically more humid than natural gas, often saturated with moisture at the temperature of the anaerobic digester or downstream processes. The present study result showed that the collected gas is analysed in portable gas analyser. The composition of the generated biogas from agricultural waste Sorghum crop residue contains methane 53.79%, carbon dioxide 29.19%, oxygen 3.09%, others 13.93% and hydrogen sulphide 0.26 ppm. A study reported by Calbry-Muzyka et al. (2022) the agricultural waste have various composition of biogas such as CH4, CO2, O2, and N2 etc. While wheat straw contains 51.68% of methane, 26.32% of carbon dioxide, 2.47% of oxygen, 19.53% others and 0.16ppm of hydrogen sulphide. Which shows in table No.2.

Table 2: Composition of generated biogas from different agricultural waste and digesters.

		RESULT in %	
Sr.no.	Name of elements	Sorghum	Wheat
1.	Methane (CH4)	53.79	51.68
2.	Carbon dioxide (CO2)	29.19	26.32
3.	Oxygen (O2)	3.09	2.47
4.	H2S	0.26 ppm	0.16 ppm
5.	Others	13.93	19.53

Conclusion

The goals of biogas production from agricultural waste will play important role for environmental sustainability and circular economy. Its also play important role in waste management that reduces environmental pollution. Furthermore, the metabolic reactions using microbes, filtration, advancement, and CO2 removal play a role in the biogas formation. Agricultural wastes are important sources especially cellulose and hemicellulose waste materials. The present study conducted for assessment of biogas production rate and screening of agro waste. Resultants sorghum waste showed more gas production than wheat straw >and coconut shells. The also asses that the higher production of biogas was seen at 21 DAD (day after digestion). The study concluded that agricultural wastes are significant biogas generation sources. Thus, choosing the majority of cellulosic agricultural plants will aid in the generation of biogas and lessen the detrimental effects of fossil fuels and agricultural wastes.

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Data Availability

Not applicable

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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