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PRODUCTION OF BIOGAS FROM MUNICIPAL SOLID WASTE FOR SUSTAINABLE DEVELOPMENT IN NEYVELI TOWNSHIP UNDER CIRCULAR ECONOMY

[1]Mamdha kumari k, [2]Sivarajan P,
[1] P.G student, [2]Associate Professor,
[1]Department of civil engineering,
[1] Annamalai university, Annamalainagar, Tamilnadu

Abstract : Biogas is an energy-rich gas produced by anaerobic decomposition or thermo chemical conversion of biomass. Biogas is composed mostly of methane (CH4), the same compound in natural gas, and carbon dioxide (CO2).Biogas is a naturally occurring gas that is generated by the breakdown of organic matter by anaerobic bacteria and is used in energy. Bio refining is an essential component for achieving a sustainable economy. This approach makes use of zero-waste technologies and generates renewable energy. In this context, anaerobic digestion (AD) allows proper waste management through controlling pollution/waste accumulation and converting organic matter into higher-value products: biogas and bio fertilizer. Neyveli Township remains a persistent economic and environmental challenge now a day. More than 80% of wastes from Neyveli township solid waste is disposed of at landfills and dumpsites. Approximate and elementary analyses of OFMSW samples were carried out to estimate the potential production of biogas and bio fertilizer. The biogas and methane production were determined by the biochemical potential of methane during one month of operation. An emerging business model competes with the dominating model. Anaerobic digestion (AD) can be used as a stand-alone process or integrated as part of a larger bio refining process to produce bio fuels, bio chemicals, and fertilizer, and has the potential to play a central role in the emerging circular economy (CBE). Carbon emissions and associated global warming have become a threat to the world, the major contributor being the extensive use of fossil fuels and uncontrolled generation of solid wastes. Waste generation has become common in all sectors involving environmental pollution and requires an immediate solution. This present scenario is the biggest strategy for gaining money through this waste was totally a good framework for a circular economy contains**.**

Keywords: **- Anaerobic digestion, biogas production, residential waste, Neyveli township, bioenergy, Biochemical oxygen demand(BOD), Chemical oxygen demand(COD), Waste-to-energy(WTE), Methane(CH4), Carbon dioxide(CO2).**

I. INTRODUCTION

Energy from biomass can make significant contributions to reducing global greenhouse gas emissions by servicing multiple sectors, including electricity, heating, and transport fuels. However, the amount of biomass is limited and influenced by competitive uses as well as environmental and economic factors (Popp et al., 2014). Wet biomass can be used to generate energy through anaerobic digestion (AD) plants, in which microorganisms decompose the organic fraction while producing biogas. Simultaneously, the resulting nutrient-rich digestate serves as a fertilizer for local agriculture. Further positive externalities of AD technology include, e.g., energy independence, soil quality preservation, and job creation (Montpart et al., 2021)

AD from agricultural residues fits into the context of the circular economy (European Commission, 2015). Restorative, it aims to keep the material and its components at their highest utility and value (Fagerström et al., 2018). Today's agro-food system is typically based on linear fluxes (e.g., import of resources, fossil fuel, and mineral fertilizers) when a circular approach should be privileged. To promote the many positive externalities of AD and justify the political support for this technology, it is crucial to investigate its many advantages. In the agricultural sector, the use of digestate instead of unfermented slurry limits water pollution and reduces the use of mineral fertilizers (Baştabak and Koçar, 2020; Holm-Nielsen et al., 2009), which production is based on fossil fuels or exhaustible natural resources (Chojnacka et al., 2019). Therefore, the replacement of fossil-based fertilizers resulting from the production of digestate should also be assessed in terms of avoided greenhouse gas (GHG) emissions and nutrient imports.

The Co-digestion (AcoD) is believed to be superior to mono-digestion in terms of a well-balanced macro- and micronutrient for anaerobic microorganism, ideal moisture content, microbial metabolism, buffer capacity, biodegradability, and dilution of toxic compounds (Prasad Lohani, 2020; Rabii et al., 2019; Shah et al., 2015a). In most cases, using a co-substrate increases biogas yields by 1.27–3.46 times over mono-digestion of the same substrate due to positive synergisms established in the digestion medium and the supply of necessary nutrients. (Chen et al., 2020; Wang et al., 2018). Unfortunately, due to the high content of non-biodegradables in dairy manure, its mono-digestion results in low methane rate and yield (Frear et al., 2011; Kalamaras and Kotsopoulos, 2014). Furthermore, the dairy manure has a higher content of nitrogen (N). That is why the dairy manure has a low C/N ratio; therefore, it is not good for microorganisms, and limits the AD process. To address this issue, dairy manure is co-digested with carbon-rich substrates such as food waste and aloe peel waste etc. (Jia et al., 2020; Abbas et al., 2020). Several studies have been conducted on AcoD of dairy manure with many other biogenic wastes such as agricultural waste (Wang et al., 2012), food waste (Latha et al., 2019), switch-grass (Zheng et al., 2015), vegetable and fruit wastes (Montoro et al., 2019). Consequently, AcoD of dairy manure with these carbon-rich wastes increases the biogas yield and provides a number of benefits for the manure and organic solid wastes recycling in terms of energy recovery and bio-fertilizer production (Holm-Nielsen et al., 2009). Among these biogenic wastes, food waste proved itself as an ideal biogenic waste for AcoD with dairy manure due to its superior composition such as high content of carbohydrate, nutritive value to microbes, quick hydrolysis process, calorific value, acidification of organic matter, and high biodegradability (Iqbal et al., 2014; Fisgativa et al., 2016).

The main limitation associated with AD of food waste alone is a pH drop in the reactor, which inhibits the activity of methanogenic bacteria (Bouallagui et al., 2005; Misi and Forster, 2001) to follow the rapid accumulation of volatile fatty acids. In this regard, dairy manure can help to restore the pH in the AD system by increasing buffering capacity, which might be beneficial for AcoD with biodegradable food waste and microbial activity (Rabii et al., 2019; Atandi and Rahman, 2012). Thereby, AcoD of food waste with dairy manure could improve nutrient balance, boost methane yield, and improve the fertilizer value of digestate (Zhang et al., 2013). When biogas externalities such as environmental, human, and animal health benefits are quantified and integrated into the overall economic benefits, biogas from AcoD of food waste and dairy manure is also a very appealing solution from a socio-economic viewpoint, such as the reduction of GHG emissions from dairy manure and food waste (Holm-Nielsen et al., 2009). A transition from a linear economy to a circular economy of resource consumption is essential for reinvesting the value of lost resources to resource-efficient products in order to create a sustainable ecosystem. Domestic digesters present a possibility to develop a circular economy based on biogas. Compared to other substrate combinations, co-digestion of food waste and poultry litter with goat dung produces more biogas. Therefore, selecting suitable co-substrates with an optimized mixing ratio can facilitate the achievement of sustainable development goals via a biogas-based circular economy (Dhungana et al., 2022). Agricultural and forest leftovers, food and animal wastes, algal biomass, municipal solid wastes, and wastewaters can be gradually processed or blended to produce fuels and chemicals (Kumar and Verma, 2021).

Pakistan is predominantly an agricultural nation, and the rural community commonly raises cattle to suit their requirements. The majority of livestock, 45.8%, was comprised of poultry, followed by buffaloes (20.6%), cattle (12.7%), goats (10.8%), sheep (8.4%), asses (1.3%), camels (0.25%), horses (0.1%), and mules (0.05%). Depending on the animal's size, weight, age, kind of feed, and other factors, various animals create varied amounts of dung. Cattle create 10–20 kg of manure per day on average, but chickens only produce 0.08–0.1 kg. Each province in Pakistan produces a sizable amount of livestock manure, with Punjab contributing the most (51% of total) in 2018. In 2018, Pakistan has a capacity for producing 417.3 (MT) of livestock manure, from which 26,871.35 million m3 of biogas might be produced, with a potential for 5521.5 MW of electricity and 492.6 PJ (Peta Joule= 1015 Joules) of heat energy. Pakistan's present energy difficulties could be resolved thanks to its suitable environment for biodigester technologies and through the effective development of anaerobic digestion (Khan et al., 2021).

The main objective of this work was to enhance the AcoD of CFW and CM by focusing on mixing ratios for biogas enhancement. The utilization of digestates obtained from AcoD systems for better nutrient management and assesses the potential role of anaerobic co-digestion from linear to bio circular economy and lastly applied the Gompetz model to verify the experimental results

III. EXPERIMENTAL METHODOLOGY

2.1Study site

The NLCIL TOWNSHIP has about 21,000 quarters of various types with 30 wards holding 1.15lakhs of population. The waste generated in the Neyveli was about 50 metric tons. Among these 10 blocks were randomly picked for the systematic analysis using the circular economy concept covering 15 houses in each ward. To improve the sustainability in MSW management, it promoted some directions to reduce the generation, encouraging recycling, and reduce biodegradable wastes and to landfill. In this context, anaerobic digestion was carried out through these regulations

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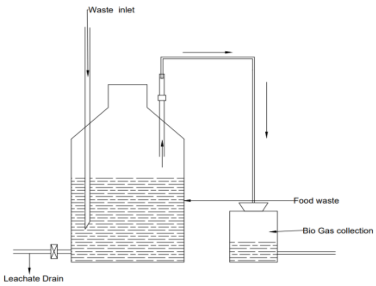
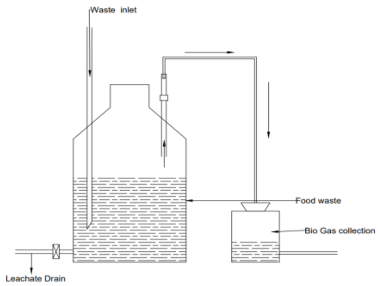
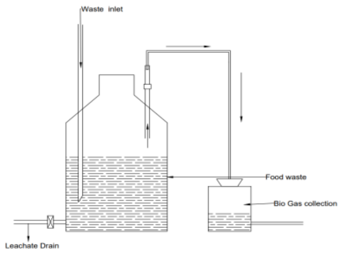
Experimental setup



Digester A



Digester B



Digester C

Figure 1. Schematic of the experimental model line diagram

Table 1: Description of the reactor design

Total volume in liter	20 L
Working volume in liter	13L
The shape of the digester	Cylindrical
Diameter of a cylinder in cm	40cm
Size in cm	16.36 cm x 22.25cm x19.36 cm (H x W x D)
Dimensions in mm	530 x 335 x 160 mm
PVC Pipes	Pipe 0.5" (length of 1m)
Pressure valves	$1^{1/2}$ and 1' inch
Reactor type	Anaerobic reactor
Material type	PET (polyethylene terephthalate)
Colour	Transparent
Type of feeding	Batch process
Method	Water displacement method
Additional equipment	Gas holder, pipelines, pressure valves, gas collection tubes, water displacement jar, leachate collection container, sealing tape, M-Seal.

II. RESULTS AND DISCUSSION

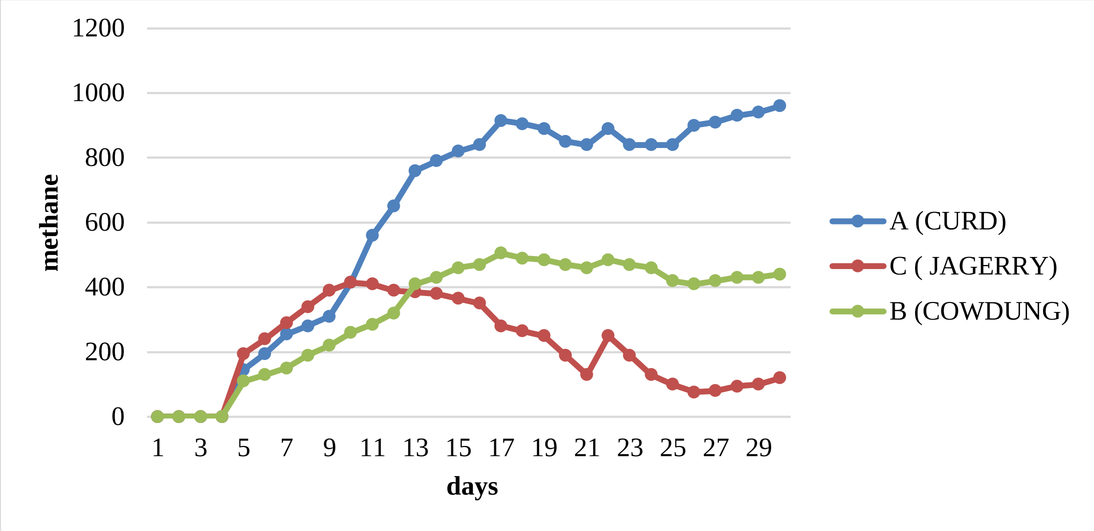
In this study, the reduced GHG emission of the biogas project is calculated for 30 days. Including operating energy consumption, substitution conventional energy emission and excrement discharge. The effects of the comprehensive utilization of biogas project on the ecological environment and sustainable development of NEYVELI TOWNSHIP is analyzed. Then the cost and income of the biogas project is calculated so as to find out the role and effect of biogas project on the development of low-carbon circular economy in the township. The income mainly includes the direct and potential marketing income, such as the fertilizer income, the environment income, etc. The total biogas yield in the neyveli township biogas project, 1336032 m^3 /month. Before that, villagers used fossil fuels, such as coal, liquefied petroleum gas, etc. The household energy consumption in the Neyveli Township before and after the construction of biogas project. The amount of fossil energy used before and after the project is 95.4% and 74.9% respectively. The GHG emissions factor of biogas is far lower than that of coal and petroleum. Therefore, before the project, 3425.37t CO_2, 4077.79kg CH_4 and 47.95kg N_2O was discharged for the household energy consumption annually, and while the project was completed, the GHG discharge is 1562.95t CO_2, 1581.92kg CH_4 and 22.14kgN_2O. The discharge of CO_2, CH_4 and N_2O is declined by 54.37%, 61.21% and 53.83% respectively. The experiments were carried out on batch Scale laboratory Digester with a total capacity of 20 Liter. The digester was made with a sampling outlet. The bottles were closed by rubber stoppers equipped with glass tubes for gas removal and for adjusting the PH. The effective volume of the reactor was maintained at 13 liters. Biogas production from the digesters was monitored daily by the water displacement method. The volume of water displaced from the bottle was equivalent to the volume of gas generated. The digesters were operated at room temperature. Food waste from all the residents as feed for the bioreactor. The wastes were sorted and shredded, then mixed several times. All reactors are loaded with raw feedstock and inoculated with curd, cow dung& jaggery each separately. Water was added to obtain the desired total solid concentration. The study had been carried out with curd, cow dung, and Jaggery as inoculums, and co-digested. The percentage of inoculums for fermentation of the organic wastes is approximal 0% to 75% for the work. The Difference between Total Solid and Dissolved Solids Was Estimated as Total Solids. Total dissolved solids (TDS) is a measure of the dissolved combined content of all inorganic and organic substance present in a liquid in molecular, ionized, or micro-granular 1n (colloidal sol) in a suspended form. In environmental chemistry, the chemical oxygen demand (COD) is an indicative measure of the amount of oxygen that can be consumed by reactions in a measured solution. A COD test can be used to easily quantify the number of organics in water.

Table 2: Parametric analysis of a waste sample

PARAMETER	OFMSW	CURD	COWDUNG	JAGGERRY
Moisture content%	30.1	30	29.5	30.2
Total Solids%	79.25	69.3	55.63	22.5
Fixed solids%	19.2	10.2	7.61	19.4
Volatile solids%	92.3	85.764	92.840	75.690
COD	3876	41636	2320	28876
PH	6.2	6.3	5.9	6.4

Table 3: comparative analysis of a biogas production

RETENTION TIME(24hrs)	A (CURD) ml	B (COWDUNG) ml	C (JAGERRY) ml
1	-	-	-
2	-	-	-
3	-	-	-
4	-	-	-
5	145	110	195
6	195	130	240
7	255	150	290
8	280	190	340
9	310	220	390
10	415	260	415
11	560	285	410
12	650	320	390
13	760	410	385
14	790	430	380
15	820	460	365
16	840	470	350
17	915	505	280
18	905	490	265
19	890	485	250
20	850	470	190
21	840	460	130
22	890	485	250
23	840	470	190
24	840	460	130
25	840	420	100
26	900	410	76
27	910	420	80
28	930	430	94
29	940	430	100
30	960	440	120



IV. Conclusions

The transition towards a more circular economy draws attention to the different means by which material excess can be fed back to production. This paper has introduced a new framework to study business models for secondary resource recovery as co-existing and potentially competing modes of material organization. Analysis of Finish biogas production through the framework allowed for the differentiation of four biogas business models and their mutual relations: (i) biogas production as waste-management and energy generation, (ii) biogas production as manure processing to support farming; (iii) biogas production as a means to enhance the utilization of rural energy potentials, and (iv) biogas production as centralized manure processing to enhance nutrient recycling. The findings show that the business models differ regarding the ways they limit the spectrum of the biomasses used as raw materials in resource recovery. The dominant model, biogas as waste-management and energy generation, is exclusive in the ways it hinders the growth potential of the more circular biogas business model emphasizing nutrient recycling and weakens the capacities of Finland to become a more circular economy.

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