PRODUCTION OF BIOHYDROGEN FROM FOOD WASTE AND SEWAGE INNOCULUM

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Abstract—

A Study was conducted for the biological production of hydrogen from food waste in an anaerobic fermenter using dark fermentation process. Sewage sludge (mainly liquid) is used as inoculum which is the main source of hydrogen producing bacteria. E.coli and Enterobactor aerogenes are the prominent bacteria's present in sewage sludge. The batch process was conducted for two days. Among various reaction constraints affecting the fermentation of food waste, a key factor is the adjustment of environmental conditions during the fermentation because various components of food waste have different characteristics of degradation. This project tries to reduce the environmental impact of sewage and food waste by utilizing it to produce Bio hydrogen.

Key words: Bio-hydrogen, E.coli, Enterobactor, Sewage sludge

I. INTRODUCTION

Dependence on fossil fuels as our primary energy source contributes to global climate change, environmental degradation, and health problems. Today, fossil fuels (coal, oil, natural gas) supply over 80% of the world's energy needs.Global trend is to move from fossil fuels to carbon free fuels, including renewable sources of energy. For India and other oil importing developing countries, energy security is the main driver for decarbonisation. The transition from a fossil fuel-based economy to a hydrogen energy-based economy, however, is fraught with many technical challenges, from the development of efficient, large-scale and sustainable H2 production systems, production of sufficient quantities of hydrogen to its storage, transmission, and distribution. We intend to provide a solution to the first part (development of efficient, large-scale and sustainable H_2 production systems) primarily.

Globally, over 95% of hydrogen is produced from hydrocarbons; about 4% is produced through electrolysis of water. Production from hydrocarbon is an expensive and hydrocarbons are limited source of energy. These methods require large inputs of electricity derived from fossil fuel combustion. Biological production of hydrogen from food waste is a sustainable H_2 production system and cost effective.

The primary objective of this idea is bio hydrogen production from food waste through anaerobic digestion. The process shares many features with anaerobic digestion, with the exception that its maximization requires that the activity of hydrogen consuming bacteria has to be avoided (i.e. methanogenic bacteria).

The implementation of bio hydrogen from food waste have dual positive impact on the society. It solves the problem of Solid Waste Management and also helps in Generation of Electricity**.**

A. Solid Waste Management

The challenge of managing solid waste in an environmental and economically sustainable manner is becoming a problem these days. Municipal Solid Waste Management (MSWM) is a challenging problem for developing countries and it can be eased further by our idea as food waste accounts nearly 70% MSW. These food wastes can be segregated at source itself and can be diverted for biological production of hydrogen.

B. Generation Of Electricity

Our idea also has huge potential to generate electricity; hydrogen generated from food waste can be used to generate electricity by passing it through hydrogen generator or fuel cell both of which are already available in the market. The Idea can be even implemented in rural India without much difficulty.

C. VARIOUS METHODS OF PRODUCING HYDROGEN:

Steam reforming of Methane and other Hydrocarbon. Non-catalytic partial oxidation of fossil fuels (POX). Auto thermal reforming .Electrolysis of water.Biomass and biological route.

II. MATERIALS AND METHODS

A. Microbial Studies For Checking The Presence Of Hydrogen Producing Bacteria:

This is a process of finding the population of bacterial growth in the samples. Take 99ml of distilled water in a conical flask add 1ml of the sample. Take 4 test tubes, mark the test tube as 10^{-3}, 10^{-4}, 10^{-5}, 10^{-6}. Add 9ml of distilled water in each of the test tubes. Take 1ml from the prepared sample and mix it in a test tube marked 10^{-3} tube. Now from this 10^{-3}, take 1ml and add it to another test tube naming it 10^{-4}. Again take 1ml from 10^{-4} test tube, mix it with 10^{-5} tube, and repeat the process till 10^{-6}. Now take 1ml from each tube and store it 4 petri dishes and add nutrient agar in 4 dishes along with PDA agar medium and Actinomycin Isolation agar medium. Incubate the nutrient agar medium at 37 °C for 24 hours. Incubate the PDA (Potato Dextrose agar) medium at 27 to 30 °C for 24 hours. Incubate the AIA (Actinomycin Isolation Agar) at room temperature for 24 hours.After the period of incubation perform the colony count to estimate the growth population of the Bacterial cells.Microbial study for checking hydrogen production was conducted for sewage sludge, kitchen waste water and diary waste.

B. Experimental Procedure for Characteristics Of Food Waste:

Preliminary experiments like total solids, volatile solid, pH, COD, moisture content were conducted at different mixing ratios using standard procedures.

Experimental Procedure for Biohydrogen Production

Hydrogen was produced through anaerobic digestion of food waste. Anaerobic digestion process includes hydrolysis, acidogenesis and methanogenesis . Hydrolysis and acidogenesis produce hydrogen gas and organic acids we will limit the reaction up to the acidogenesis stage to produce maximum amount of hydrogen by inhibiting methanogenic bacteria. Sewage sludge was used as inoculum for batch test which was collected from a anaerobic digester of a Sewage Treatment Plant (SPT) located in Perungudi, Chennai. Heat treatment was carried out on the collected sludge in order to inhibit methanogenic bacteria, in an air oven at a fixed temperature of 80°C for about 15 minutes. After heat treatment, samples of treated sewage sludge were used as inoculum for hydrogen production. The inoculum was then mixed with appropriate ratio of food waste; fermentative process will take two days before hydrogen gas is generated. Hydrogen generated can be collected by the downward displacement of water.

As from the Fig.2, Stage II produces the maximum amount of hydrogen. Stage III produces methane. The anaerobic digestion was limited at stage II by inhibiting methanogenic bacteria (by giving thermal shock) and providing favorable condition for hydrogen producing bacteria such as E.Coli and Enterobactor aerogenes to grow. Currently food waste is discarded via land filling which produces green house gases and is an epicentre for diseases.Presently biogas is generated from organic waste and used as fuel which in turn produces harmful gases like CO_2 etc which further degrades environment; hydrogen on the other hand is a clean and efficient fuel.Moreover the waste got from the reactor after the production of hydrogen can be used as manure in agricultural field or as vermin compost.

Fermentative production of hydrogen from food wastes were conducted at a mesophilic process temperature of 35°C (Room temp). Sludge was subjected to thermal pre-treatment to inhibit the methanogenic bacteria activity. The tests were performed using a given quantity of material, inoculated with anaerobic sludge collected from sewage treatment plant, in anaerobic conditions and at a controlled temperature (36°C ± 1 °C).

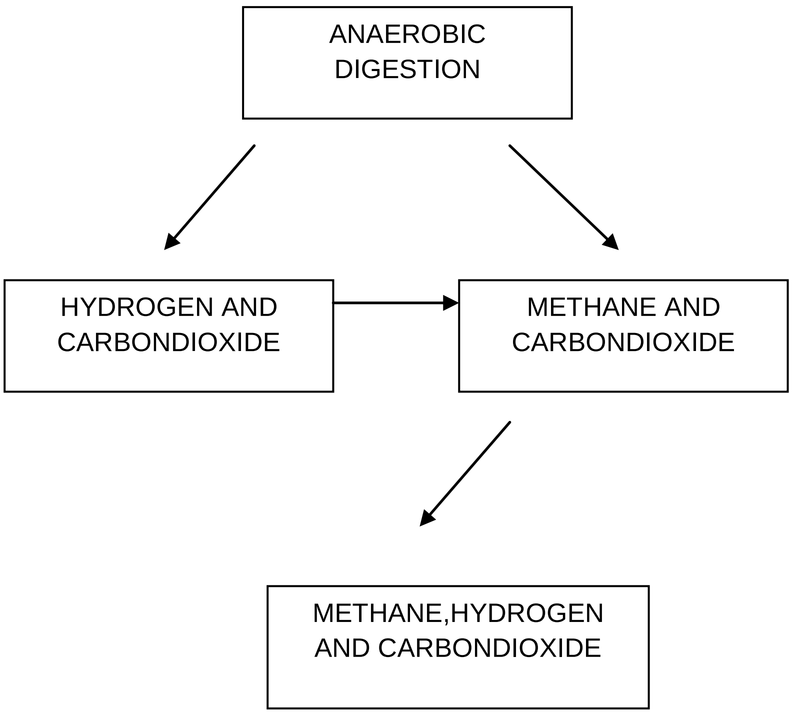

Fig 1. Basic Flow diagram

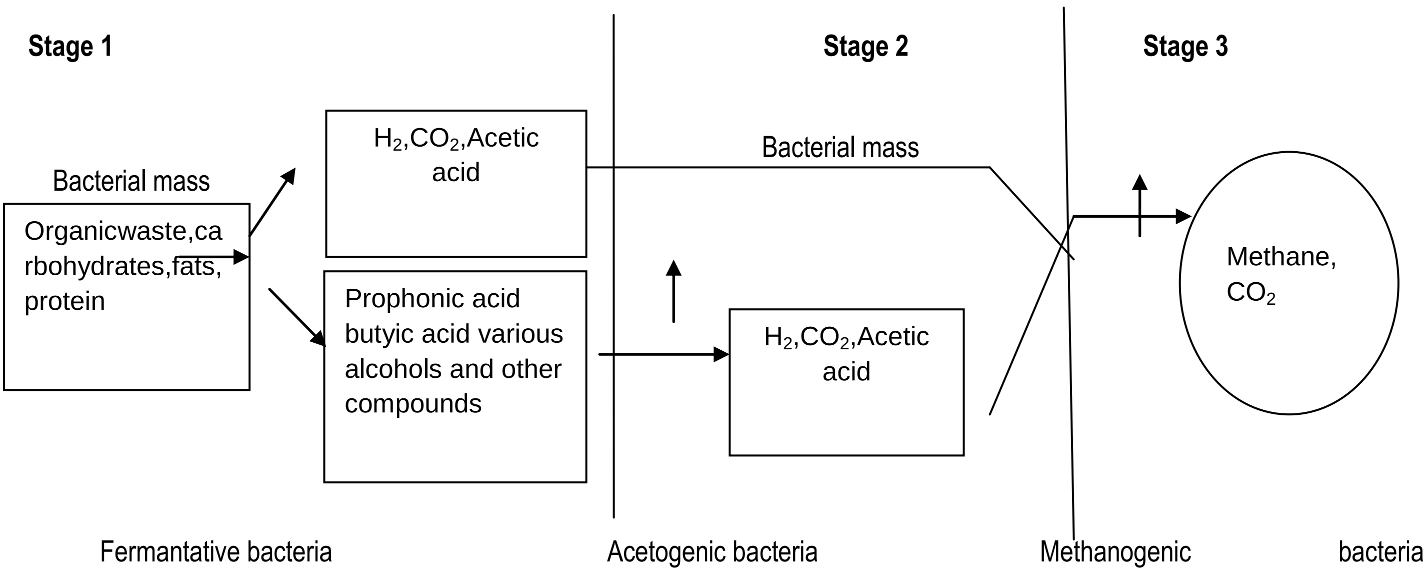

Fig.2 Stages in Anaerobic Fermentation

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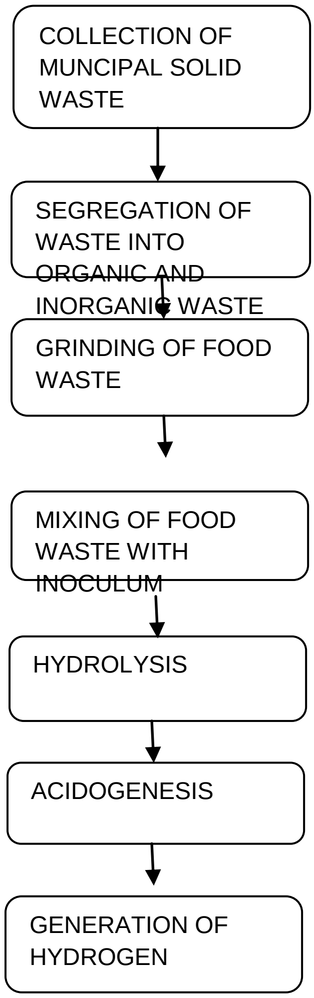

The concept can be extended for production of electricity through one of the following ways

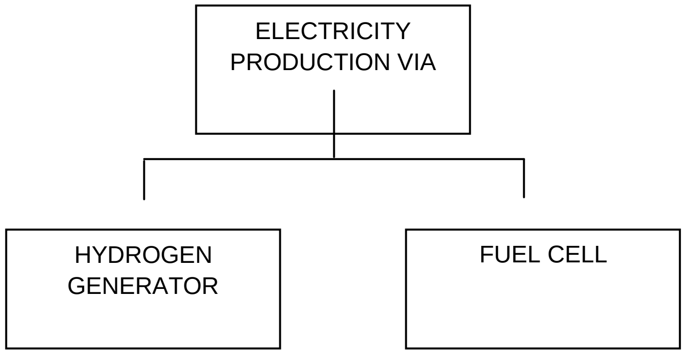

Fig .3 Fermentative Production Of Hydrogen

Moreover the waste which is accumulated in the reactor can be used for making good manure.

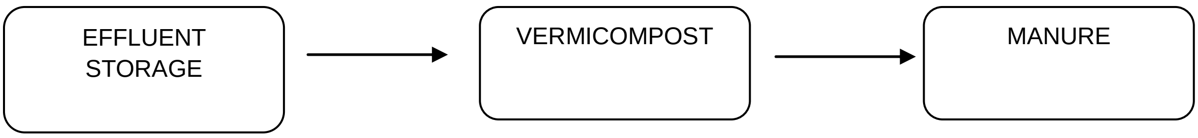

Fig .4 Distribution of waste from the reactor

Fig .5 Bio-Hydrogen Production

Different food to sewage ratios were considered for the optimization of hydrogen production (100:0, 60:40, 50:50, 20:80).This mixture was fed into a reactor where anaerobic digestion takes place. Normal room was maintained for the economical production of hydrogen i.e. 35^0 c. Pre-heating was carried out for sewage sludge to kill methonogenic bacteria, sewage sludge was heated at 80^0C for 15mins.The food waste was well grinded and mixed with sewage sludge. The reactor was covered with black insulation tape for proper dark fermentation to take place. The feed was sent in at the top of the anaerobic digester. A provision for gas collection was given at the side of the reactor with the help of a valve. A valve was connected to a tube which is connected to the downward displacement column where the gas gets collected. From these experiments we found out that 60:40 is the optimized ratio for maximum hydrogen production. The purity of hydrogen obtained from food waste was determined using gas chromatography.

III. RESULT AND DISCUSSION

From the table it can be concluded that sewage sludge has the maximum hydrogen producing bacteria. E.coli and anterobacter are the prominent bacteria present in sewage sludge.

Table .1 Microbial population in waste

S.No	SAMPLES	MICRO-ORGANISMS	MICROBIAL GROWTH FOR DIFFERENT DAYS			
			2rd	4th	6th	8th
1.	Sewage sludge	Bacteria	34.5×10^5	45.2×10^5	48.5×10^5	51.3×10^5 *
		Yeast And Mould	12.8×10^5	14.6×10^5	17.2×10^5	19.8×10^5
		Fungi	7.0×10^5	12.3×10^5	15.4×10^5	19.8×10^5
2.	Kitchen waste	Bacteria	32.6×10^5	43.1×10^5	44.9×10^5	47.0×10^5
		Yeast And Mold	10.1×10^5	13.7×10^5	16.2×10^5	17.6×10^5
		Fungi	6.4×10^5	11.2×10^5	14.9×10^5	19.0×10^5
3.	Dairy waste	Bacteria	31.5×10^5	41.1×10^5	42.3×10^5	46.3×10^5
		Yeast And Mold	9.3×10^5	11.9×10^5	14.4×10^5	16.8×10^5
		Fungi	6.1×10^5	11.0×10^5	13.8×10^5	18.8×10^5

Table .2 Yield Percentage For Food Waste And Sewage Sludge

S.NO	RATIO	YIELD %	
		H_2	CO_2
1	100:0	1	99
2	60:40	4	96
3	50:50	2.5	97.5
4	20:80	3	97

Table .3 Table For basic parameters of food waste

S.No	Ratio (F.W: S.I)	Total solid (%)	Volatile solid (%)	pH
1	0.100	30.1	94.68	3.78
2	20:80	53.97	97.31	3.71
3	50:50	64.74	96.88	3.93
4	60.40	61.41	94.52	3.81
5	80.20	47.15	95.61	3.88

The Table results the various ratio of food waste and sewage inoculum .Basic parameters like total solid, volatile solid, pH was determined. This was done for the characterization of food waste.

IV. CONCLUSION

Study for the production of bio hydrogen was conducted as a part of solid waste management. From the bacterial studies it was concluded that sewage has more hydrogen producing bacterial when compared to kitchen waste water and dairy effluent. Food waste contains minimum amount of hydrogen producing bacteria but as a part of solid waste management solid waste in mixed with sewage inoculum. Methane producing bacteria is suppressed at the first stage of the experiment my pre-heat the sewage inoculum at 80^0 C which kills the methenogenic bacteria.

Characterization of food waste is done by determining the various parameters like total solid, volatile solid, pH etc. Optimization was carried out and it was concluded that 60:40 (food waste: sewage inoculum) has more amount of hydrogen content.. Total solid, volatile solid pH for the ratio 60:40 was 61.41%, 94.52%, 3.81 respectively. Maximum hydrogen production took place on the second day and the yield obtained was 4% hydrogen, 96% carbon dioxide and negligible amount of other trace gases.

However this yield can be improved with further research and optimization. Kitchen waste water is another source of hydrogen although the amount of bacteria content is comparatively less compared to sewage sludge. Theoretical experiments was conducted to determine energy balance, material balance and design of the reactor.

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