ANALYSIS OF BIOGAS PRODUCTION FROM MUNICIPAL SOLID WASTE AND ITS UP-GRADATION THROUGH A LOW-COST METHOD

Submitted in the partial fulfilment of the requirement of the degree of

MASTER IN SCIENCE IN BIOTECHNOLOGY

By:

Aaina Sharma (207817)

Under the Supervision of

Dr.Sudhir Kumar

Dr.Ashish Kumar

Submitted to

Department of Biotechnology and Bioinformatics

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

DEPARTMENT OF BIOTECHNOLOGY& BIOINFORMATICS

WAKNAGHAT, HIMACHAL PRADESH-173234

TABLE OF CONTENTS

DECLARATION BY STUDENT

I hereby declare that the thesis work entitled "Analysis of Biogas Production from Municipal Solid Waste and its upgradation through a low-cost method" submitted to the Department of Biotechnology and Bioinformatics, Jaypee University of Information Technology Solan (H.P), is a bonafide record of the original work done by me. The work was carried out under the supervision of Professor Sudhir Kumar and the co-guidance of Dr. Ashish Kumar.

Aaina Sharma (207817)

Department of Biotechnology and Bioinformatics

Jaypee University of Information Technology

Solan (H.P)

Date: May 2022

This is to certify that the above statement made by the student is true to the best of my knowledge.

SUPERVISOR'S CERTIFICATE

This is to certify that the thesis work titled "Analysis of Biogas Production from Municipal Solid Waste and its upgradation through a low cost method" by Aaina Sharma during the end semester in May 2022 in fulfilment for the award of the degree of Master of Science in Biotechnology of Jaypee University of Information Technology, Solan has been carried out under my supervision. This work is a bonafide record of her original work. It has not been submitted elsewhere for any other degree/diploma.

Dr. Sudhir Kumar

Professor and Head

Dept. of Biotechnology and Bioinformatics

Jaypee University of Information Technology

Waknaghat, Solan

Himachal Pradesh-173234

Dr. Ashish Kumar

Professor and Head

Dept. of Civil Engineering

Jaypee University of Information Technology

Waknaghat, Solan

Himachal Pradesh-173234

Acknowledgement

I would like to express my gratitude and appreciation to all those who gave me possibility to complete this thesis report. The M.Sc. Project has been an audacious journey for me. First of all, I want to thank almighty who blessed me with the opportunity to study in Jaypee University of Information Technology (JUIT) and pursue the project.

I would like to thank JUIT for providing constant assistance in the journey. I owe sincere gratitude to Prof.Sudhir Kumar, the HOD of dept. of Biotechnology and Bioinformatics and Prof. Ashish Kumar, the HOD of Civil Engineering dept. I take this opportunity to genuinely thank them for their constant guidance. I would also like to acknowledge with much appreciation the crucial role of the staff in biotechnology laboratory and special thanks to Ms. Pooja mam, the PhD scholar at JUIT for her support. I would like to give special thanks to Mr. Karam Dass and Mr. Amar Kumar for the technical assistance throughout the project.

I owe my gratitude to JUIT authorities for providing me opportunity to pursue my project.I'm immensely indebted to my parents (Mr. Pritam Sharma and Mrs. Anjana Sharma) for their support and constant love. I'm deeply thankful to them for trusting me and encouraging me for studies.

The project helped to inculcate morals within me. The journey taught me patience, consistency and perseverance.

Aaina Sharma (207817)

List of Figures

List of Tables

Abstract

Biogas production has the potential to meet future fuel demands. If we upgrade biogas, remove CO_2 and H_2S and turn it into biogas, we can use biogas as fuel for vehicles. The amount of biogas produced depends on a variety of factors, but mainly on the type of raw material used and the environmental conditions. As the population grows and the consumption of these fuels gradually increases, fossil fuels used as an energy source are in short supply every day. Therefore, biogas is an alternative fuel source. The amount of waste generated in cities is so large that the disposal of this amount of waste becomes a problem. Biodegradable waste can be used in the production of biogas. Biogas solves important problems such as power generation, vehicle fuel and can be used for cooking.

List of abbreviations and symbols

C/N – carbon to nitrogen ratio

MSW- Municipal solid waste

ULB – urban local bodies

O_{2-} oxygen

CO_2 – carbon dioxide

H_2S – hydrogen sulphide

CH_4- Methane

CPCB- Central Pollution Control Board

MT- million tonnes

KVIC – Khadi and Village Industry Boards

BOD- Biological oxygen demand

COD- Chemical oxygen demand

TPD – Tonnes per day

Chapter 1

Introduction

1.1 Municipal Solid Waste

The way people live causes various global changes, such as an increase in fuel use and trash production. Changing lifestyles cause these changes. Population growth and rising needs increase the amount of trash that must be disposed of. This increases demand for garbage management. Most solid waste is biomedical or municipal [14]. "Municipal solid waste" (MSW) is an acronym for "community trash" This category includes residential, urban, industrial, institutional, commercial, and demolition rubbish. Inaccurate data collection and processing pose threats to human and environmental health. In affluent nations, solid waste and wastewater are collected, utilized, and recycled to recover energy [12]. In developing nations, proper waste collection and disposal are not yet possible for most of the population, and integrated treatment facilities have not yet been created. Developed nations are also distinct. Recent neighbourhood events have raised citizens' attention in environmental problems including waste management and the greenhouse effect. Biogas production from solid waste decreases rubbish and greenhouse gas emissions. This might enhance biodegradable rubbish management and cut greenhouse gas emissions.

1.2 Mismanagement of Municipal Solid Waste

Improper management of municipal solid waste (MSW) is currently one of the country's biggest challenges as it affects the purity and cleanliness of the environment. Municipal waste (MSW) includes household waste, harmless market waste, garden waste, agricultural waste, and street cleaning. The ongoing urbanization in India will lead to a significant increase in waste over the next 20 years. The Central Pollution Control Board estimates that waste will increase from the current 48 million tonnes (MT) per year to 300 tonnes per year (from 490 g per capita to 945 g per capita) by 2047.). By 2047, the estimated land transfer needs will be 169.6 square kilometres, compared to 20.2 square kilometres in 1997. (CPCB 2000a) [12]. India currently emits 48.0 tonnes of household waste annually. The urban population of India is increasing at a rate of 3 to 3.5% per year, while the age of per capita waste in India is increasing at 1.3% per year. The age of apostasy in India is increasing by about 5% each year. To dispose of waste generated in metropolitan areas, local governments donate 35-50% of the available resources.

Not only various metro cities/towns/states, but typically the entire country of India is suffering from poor MSW management, and one of the main reasons is inappropriate source segregation and low community engagement. Otherwise, it is not a difficult work, but it now appears unattainable. Along with community participation, there is a lack of communication between Urban Local Bodies and the community. Every waste generator now has the responsibility of segregating and storing waste in distinct bins, such as biodegradable, non-biodegradable, and home hazardous waste, before passing it on to the collection authorities. As a result, every trash generator will be responsible for sorting their waste, while the respective municipality would be responsible for door-to-door pickup. Waste collection from residences and communal bins must also be done in a separate manner. It must be ensured that waste is properly covered and does not spill during transportation.

Chapter -2

2.1 Biogas Technology

Biogas is an energy-rich gas produced by anaerobic decomposition of biomass. Methane (CH_4) is the same component found in natural gas, and carbon dioxide make up the majority of biogas (CO_2). Raw(untreated) biogas can have a methane percentage of 40–60%, with CO_2 accounting for the majority of the rest, along with small amounts of water vapour and other gases. Biogas can be used directly as a fuel or treated to remove CO_2 and other gases before being used in the same way that natural gas is. Biomethane or renewable natural gas are two names for treated biogas [10].

Biogas technology is important not only for supplying fuel, but also for biomass resources, agriculture, forestry, development of livestock and fisheries, development of agricultural economy, environmental protection, realization of agricultural recycling, and improvement of hygiene. Rural conditions. There is great potential for biogas production and application in rural India. Biogas has been promoted primarily in recent decades.

With rising oil prices, the basic energy supply to rural homes, especially cooking and lighting, has become an important energy issue. Biogas is a renewable energy source that can be obtained from wastewater, chicken, cattle and pig manure, organic waste from the market and food industry, and other sources. Biogas production provides a renewable, environmentally friendly and sustainable agricultural system. Biogas usually contains 55-80% methane gas (CH4) [8]. Biogas production systems have many advantages, including greenhouse gas removal, energy sources, and fertilizer benefits [9]

Biogas technology is an alternative to meet growing energy demand in emerging markets and rural areas. The fundamental advantage of this technology is that it is environmentally friendly as it enables efficient waste utilization and nutrient recycling. Biogas technology can be used both domestically and in communal areas. Biogas is a versatile energy source that can be used in a variety of applications such as cooking, lighting, and power generation. Anaerobic digestion of biodegradable waste such as animal manure, agricultural waste and kitchen waste produces biogas. Biogas plants that use bovine (cattle and buffalo) manure have been standardized in recent years and are now becoming widespread in India. Only three designs, KVIC (supported by Khadi and Village Industries Commission of India), Janata and Deenbandhu, are nationally popular. The design promoted by KVIC is a floating gas storage facility, and the designs of Janata and Deenbandhu are fixed dome facilities. In fact, the Janata biogas plant is gradually losing market share in the currently most popular Deenbandhu plant with its relatively new design [4]. Biogas is formed when bacteria break down organic waste in the absence of oxygen (anaerobic digestion). Methane is like liquefied petroleum gas that can be burned for cooking and lighting. It can also be used to power a motor or generate electricity with an internal combustion engine. Electricity is an important factor in achieving national development goals. The availability of sufficient quantity of electricity at a reasonable price will drive economic growth. With the depletion of fossil fuels and the deterioration of the environment, building new power plants based on renewable energy and improving technologies to improve energy efficiency is the best way to meet the needs of electrification.

2.1.1 Factors on which the production of Biogas depends

Biogas technology is an alternative to meet growing energy demand in emerging and rural areas. The fundamental advantage of this technology is that it is environmentally friendly as it enables efficient waste utilization and nutrient recycling. Concentration of substrate, quantity, rate, and composition depends on various factors like:

- Feeding rate
- Carbon to Nitrogen Ratio
- pH value
- Population of bacteria
- Temperature and Chemical Inducers are all factors need to be considered.

2.1.2 Advantages of Biogas

• Biogas systems produce clean energy for domestic use. There is no requirement to spend money on fuel after investing initially in the system, and there is no smoke produced from this system.

• Biogas cooking is faster and easier than cooking with wood.

• Bacteria in cattle manure are killed by biogas systems.

• While producing biogas, slurry is produced as by-product which can be used as manure in fields.

• Biogas systems help combat global warming by burning methane from organic waste instead of letting it escape into the atmosphere, which contributes to the greenhouse effect. It also helps conserve trees by allowing us to maintain more positions [2].

2.1.3 A Biogas digester

The biogas digester is an all-in-one solution that can, among other environmental and economic goals, reduce greenhouse gas emissions, provide renewable energy, stabilize organic wastes, eliminate odours, remove pathogens, and produce organic fertilizer. Other potential benefits include eliminating odors, eliminating pathogens, and producing organic fertilizer. The two basic classifications of biogas digesters are small-scale digesters and medium- to large-scale digesters, and each of these types of digesters may be further classified into further categories. The major objective of medium- and large-scale biogas digesters, on the other hand, is to lower COD and BOD levels while producing biogas as a byproduct in exchange for a tipping fee. These digesters are intended for the treatment of industrial and municipal organic waste. On the other hand, small-scale biogas digesters are intended for the treatment of organic waste created by companies and municipalities. The reduction of COD and BOD is the major purpose of these digesters, and the generation of biogas serves as a tipping fee. Despite decades of extensive study and development of biogas digesters on a medium or large scale [9], it is widely believed that the usefulness of methane digesters on a smaller size is significantly underappreciated. While in recent years the advantage of using small-scale digesters to meet household energy requirements in the course of household waste stabilization and organic fertilizer production has stepped into the vision of modern farmer families, while in recent years the advantage of using small-scale digesters to meet household energy requirements in the course of household waste stabilization and organic fertilizer production has stepped into the vision of modern farmer families.

In a biogas fermenter, organic waste is turned into biogas via the fermentation process. There is a wide range of possible sizes for digesters, ranging from small residential facilities to enormous commercial facilities with capacity of thousands of cubic meters. Biogas facilities rely on farmers to provide them with cow manure. Both the Chinese Fixed Dome Biogas Digester and the Indian Floating Cover Biogas Digester are examples of straightforward designs for biogas digesters. Both digestion tanks use the same digesting process, but their gas collecting methods are distinct from one another. When gas is produced, the cover may rise, and the type with the floating cover acts as a storage chamber. On the other hand, the type with the fixed dome has a limited capacity for storing gas and needs a suitable seal to prevent gas leakage. Both are designed to be included in manure or other forms of animal waste. The waste is fed into the fermenter via the inflow pipe, and the fermentation process takes place in the digestion tank. The temperature of the operation is particularly significant because methane-producing bacteria function most effectively at temperatures between 30 and 40 degrees Celsius or between 50 and 60 degrees Celsius. It might take anywhere from two to eight weeks to digest a collection of garbage, depending on the weather. The excess liquid fertilizer is collected at the output, where it may be recycled for further use [8]. In order to construct a biogas plant, you will first need to determine the capacity of the fermenter. This comprises the amount of biogas required to meet daily cooking (and lighting) requirements, the availability and quantity of animal dung and water (the number of water, cattle, goats, and other animals), and fermentation. The amount of biogas required to meet daily cooking (and lighting) demands. The answer to this question is determined by the components that are required to construct the tank. (Bricks, and so forth). The production of biogas at a facility needs a reliable source of water supply [9].

The biogas manufacturing process involves a series of chemical processes:

$C_6H_{12}O_6 \rightarrow 3CO_2 + 3CH_4$

$CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O$

$CH_3COOH \rightarrow CH_4 + CO_2$

2.1.4 Biogas plant designs in India

The aim of this project was to frame and construct an anaerobic digester that can meet the following requirements.

1. The design should aim to create the most biogas per unit of time possible.
2. Be an anaerobic digester with constant flow. This has been chosen because it appears to be the most practicable design for continuous operation in an agricultural setting.
3. It should be simple and easy to follow, so that even a non-technical person can figure out the purpose and theory behind each design element. When looking at the design, the purpose is to get people thinking about and comprehending the requirement for controlled anaerobic digestion and the continuous flow paradigm.
4. Be a long-lasting, small, and versatile design that can be moved about to be presented if necessary.

5. Be operated with as little monitoring, regulating, and modifying as possible.
6. Attempt to decrease the time and money spent on maintenance.
7. Attempt to keep the amount of setting up and running the digester as low as possible without sacrificing the digester's performance or the brief's other requirements.

2.1.5 Types of Biogas Digester

2.1.5.1 Fixed dome digester

An underground biogas plant with a fixed dome. There are three main integration components. Animal excrement is mixed with water in the mixing chamber before being placed in the digestive tank. The digestive tank ferments waste and water. The chamber produces methane and other gases, pushing fertilizer and slurry out of the ground into the expansion chamber. The expansion chamber collects fertilizer and additional fertilizer. When gas is used, the slurry and fertilizer flow back into the digestion chamber, pushing the gas up and using it. When the amount of additional fertilizer in the chamber exceeds the capacity of the chamber, the fertilizer is drained. When gas is produced in the pit, the gas pressure pushes the fertilizer and slurry at the bottom of the pit into an expansion chamber called a dynamic system. When gas is used, the slurry in the expansion chamber flows back into the digestion chamber, pushing the gas into the digestion chamber for use. This happens on a regular basis. Fixed dome biogas plants have lower operating costs. It's easy because there are no moving parts. The system lasts longer (more than 20 years) because there is no rusted steel. The plant is built underground, protecting it from damage and saving space. The underground digestion tank is protected from low temperatures at night and in winter, but it takes longer for the digestion tank to warm up in summer.

The fermenter's temperature remains constant during the bacteriological process. It takes a long time to establish fixed dome facilities, but they also provide jobs in the area. It's tough to set up a permanent dome system. Biogas plants should only be established in places where the process can be monitored by trained biogas specialists. Equipment that isn't airtight may not be airtight at all (porous and cracked). There is a dome-shaped fermentation vessel with a fixed rigid gas-holder and a replacement shaft, which is often referred to as a "reservoir" in the fixed dome system. As the gas rises in the fermenter, it fills the top portion. Fertilizer is pumped into the expansion tank when gas production starts. The pressure of the gas is increased by the volume of gas held, which is the height difference between the two sludge levels. The gas pressure will be lower if the gas tank is low [9]. Initial cost and lengthy service life are the main benefits of permanent domes. Moving or corroded elements are completely absent from this model's construction. There is a lot of room for storage and insulation in this small design. The structure encourages local businesses to locate there. Advantages include a lack of moving parts and corroded steel components, as well as minimal construction costs. The lifespan of a fixed dome system may be quite lengthy if it is designed appropriately. Protected from temperature variations, the fermenter is housed in an underground location to conserve space. Work opportunities for skilled construction employees are created by new construction projects. And the cons of this stove include: Due to its airtight design, Masonry gas tanks need specific sealants and specialized technical abilities. Gas leaks occur often. It is difficult to utilize gas if the pressure fluctuates. Gas production is not readily apparent and the plant's operations are difficult to comprehend. For systems with fixed connection, precise level planning is required. Bedrock excavation is tough and expensive. Cons: The brick gas storage sometimes has airtightness issues, which is a drawback (small cracks in the upper masonry can lead to severe biogas loss). As a result, only experienced biogas specialists should supervise the installation of permanent dome systems. The quantity of stored gas affects the pressure of the gas. Even if the temperature is kept low by the building of an underground chamber, the chamber itself is not immune to the effects of high temperatures. Only an experienced biogas specialist can oversee the building of a fixed dome system. Cooking cans, on the other hand, are normally kept at a more mild temperature than underground buildings.

The following kinds of fixed-dome digesters may be further categorized:

1. China's fixed-dome plant is the most widely used form of dome plant in the world today. Millions of these have been constructed in China. Digestion takes place in a cylindrical container with a circular bottom and top.
2. To counter China's fixed dome plant, the Janata model was India's first attempt at a fixable dome. It's no longer under construction. Several facilities have gasholder cracks as a consequence of the building approach.
3. By using a hemisphere digester and better structural design, India's replacement for the Janata plant, Deenbandhu, was more crack-resistant and consumed less material than the Janata plant.

4. On top of that, the CAMARTEC model uses just one rigid foundation ring and one calculated fraction joint, known as the "weak/strong ring," to create a simpler dome shell structure. Late in the '80s, a team in Tanzania set out to construct it.
5. The Nicaragua design has been improved with the AKUT fixed dome plant. Between 2 and 19,4 m3 may be found in gas storages, whereas digester capacity ranges from 8 to 124 m3 for gas output that can reach 60 m3/d or more. The smaller the unit, the more often it is used for small-scale production, such generating electricity. With a cylindrical bottom and a spherical top, it's a cylinder. Expansion chambers discharge excess pressure.
6. AKUT Maendaleo (kisuaheli "progress"): A gas storage ballon is added to the digesting chamber to collect access gas. You might use this with remanufactured diesel generators.

2.1.5.2 Floating type digester

The first floating drum biogas plant, known as the Gobar gas plant, was designed in 1956 by Jashu Bhai J. Patel of India. An underground fermenter (cylindrical or dome-shaped) and a movable gas holder form a floating drum system. The gas holder floats on a fermented suspension or a unique water jacket. The gas is collected in a gas drum that moves up and down depending on the amount of gas stored. The guide structure prevents the gas drum from tipping over. The drum moves up when biogas is generated and moves down when biogas is consumed. Even high solids boards will not stack if the drum floats on the water jacket. Floating drum systems have become obsolete after the advent of cheap Chinese fixed domes due to high investment and maintenance costs and other design flaws. The disadvantages of this type of cookware are: Steel drums are expensive and time consuming to maintain. Rust removal and painting should be done on a regular basis. Drums have a limited lifespan (up to 15 years, about 5 years in tropical coastal areas). With fibrous substrates, gas containers tend to "clog" the resulting scum.

There are different types of floating-drum plants:

1. Floating drum biogas plants with cylindrical digesters, such as the KVIC, are the oldest and most frequently utilized in India.
2. hemispherical digester in the Pragati model
3. Gauntlet of steel and plastic foil model of Ganesh

4. Prefabricated reinforced concrete composite modules are used to construct the floating drum plant.
5. The floating-drum plant is constructed of fiber-glass reinforced polyester.
6. plants built of plastic water containers or fiberglass drums: ARTI Biogas plants, low-cost floating-drum plants
7. A hemispherical digester with the process stability of a floating-drum digester and the extended life of a water jacket is the Borda plant's combination.

2.1.5.3 Bag type digester

A balloon plant integrates a digester and a gas holder inside a heat-sealed plastic or rubber bag (balloon). The gas is collected in the balloon's upper section. The entry and outflow are directly connected to the balloon's skin. the gas pressure can be increased by putting weights on the balloon. The skin may gets damaged if the gas pressure exceeds the tolerance limit of the balloon, due to this reason safety valves are necessary. A gas pump is needed if higher gas pressures are required. Specially stabilised, reinforcedplastic are preferred since the material should be weather and UV resistant. The useful life of a product is usually between 2 and 5 years. Advantages of this digester are Low-cost prefabrication, simple construction, easy transportation, shallow installation suitable for use in areas with a high groundwater table; high-temperature digesters in hot climates; simple cleaning, emptying, and maintenance; difficult substrates such as water hyacinths can be used[9].If local maintenance is or can be made possible and the advantage of the cost is significant, balloon biogas plants are advised. And the disadvantages are Low gas pressure makes it necessary the usage of gas pumps. During the operation, scum cannot be discarded; Plastic balloons have a limited useful life, are subject to mechanical damage, and are not available locally. Furthermore, local craftsmen available are rarely capable of repairing a broken balloon. There is limited opportunity for self-help because there is little capacity for creating local jobs[8].

2.1.6 Biogas technology in India and it’s potential

It is estimated that India can produce 6.38 x 1010 m^3 of biogas annually from 980 million tonnes of cow dung produced by 300 million cattle. The heat capacity of this gas is 1.3x1012MJ. In addition, 350 million tonnes of manure and biogas will be produced [5]. Apart from the 4.75 million domestic biogas plants set up in India for the potential of 12 million people, small industrial plants, livestock farms, poultry farms, distilleries, tanning factories, hotels, restaurants, barracks, and Other places. MSW has the potential to generate 3369 million cubic meters / day from 9.23 million cubic meters / day. With 512.06 million livestock and a total of about 300 million (299.98 million), there is ample room to build a biogas plant (consisting of cattle, buffalo and yaks) [5].The cattle sector accounts for the majority of India's GDP and is expected to continue to grow. Due to its direct and indirect benefits, the spread of biogas technology has benefited Indian farmers. Like LPG, biogas, untreated, can be used as a clean fuel for cooking, lighting, motive power, and power generation.

When used with a diesel engine and using a 100% biogas engine, diesel can be replaced in up to 80% of the time and up to 100% of the time [4]. Biogas can also be refined and upgraded to have a methane purity of up to 98%, making it suitable as an environmentally friendly and clean fuel for transportation or filling cylinders at high pressures up to 250 bars and compressed. You will get a biogas (CBG) lead that has been refined.The biogas plant was originally developed to break down animal manure. However, over time, many types of biomass materials and techniques for biomethanation of organic waste have been developed. Biogas plant designs range from 0.5 m cubic to 1000 m cubic unit size and above, and multiples of this can be built for larger biogas plants, depending on the availability of raw materials. Institutional and industrial / commercial purposes. Industrial and municipal waste-based biogas plants can produce up to 15,000 to 20,000 m^3 of biogas per day [6]. Dairy farms, municipal solid waste, crop residues and agricultural waste, vegetable markets, food waste, communal toilets, sewage sludge, distilleries, dairy products, pulp and paper, poultry, industrial waste including meat treatment plants (waste water) (Excluding), and the sugar industry is about 48383 million m3 per year. This amount of raw biogas can be upgraded and bottled for use as fuel for automobiles.
.

2.1.7 Off-grid Biogas Power Generation and Thermal Application Program (BPGTP)

Biogas plants in the United States are a reliable source of distributed renewable energy for a variety of purposes, including home heating, cooking, electricity generation, and other forms of thermal energy use. Biogas produced in biogas plants with capacities ranging from 30 m3 to 2500 m3 is used to create electricity in the 3kW to 250kW power range as well as thermal energy for heating and cooling in this distributed renewable energy source.

If you have a lot of organic waste that you don't want to go to waste, you may utilize it to make biogas in a plant that can subsequently be used to generate energy or heat. Individual dairy and poultry facilities, dairy cooperatives, and other electrical, thermal and cooling energy requirements for facility operation are particularly well-suited to these enterprises' off-grid power demands. Farmers, beneficiaries, businesses, dairy farmers, and co-operatives may save money and generate more money as a consequence of installing biogas systems in DG sets. By minimizing the usage of chemical fertilizers and pursuing other profitable undertakings, such as organic farming, biogas projects may earn extra income while saving money on chemical fertilizer costs.

2.2 IEA Report

2.2.1 IEA (International Energy Agency) Report of Annual Biogas Production in 13 different countries

IEA is an international organization that was established in 1974.it is formed to regulate the stability of the international oil supply, basically, this organization focuses on renewable energy resources. In this report various countries like Austria, Brazil, Denmark, Finland, France, Germany, Norway, the Republic of Korea, Sweden, Switzerland, the Netherland, and the United Kingdom participated[2]. These countries provided different data like how much biogas is produced yearly, where this gas is utilized, what are the financial support system provided, from where this biogas is produced what kind of feedstock is used to produce biogas, and last how much electricity is produced from the biogas because in most of the countries biogas produced is used to produce electricity[2]. In table 3.1, we can see the comparison of biogas produced between different countries.

NAME OF THE COUNTRY	PRODUCTION OF BIOGAS	UTILIZATION OF BIOGAS	ANNUAL BIOGAS PRODUCTION	ELECTRICITY PRODUCED
AUSTRIA	Waste water treatment plants	Electricity generation	585 GWh/year	564GWh
	Landfills	Heat production		
	Agriculture	Vehicle fuel		
	Biowaste	Flare		
BRAZIL	Sewage sludge	Electricity	679GWh/year	80 MW of 11337 MW is produced
	Biowaste	Heat		
	Agriculture	Vehicle fuel		
	Industrial waste	Flare		
	landfills			
DENMARK	Sewage sludge	Electricity	1218GWh/year	808GHh/year
	Biowaste	Heat		
	Agriculture	Vehicle fuel		
	Industrial	Flare		
	landfills			
FINLAND	Sewage sludge	Electricity	688GWh/year	100KVA ,160GWh
	Municipal solid waste	Heat		
	Biowaste	Vehicle fuel		
	Industrial wastewater	Flare		
	landfills			
FRANCE	Sewage sludge	Electricity	3200GWh/year	1273GWh/ear
	Biowaste from MSW	Heat		
	Industrial	Fuel for vehicles		
	On-farm and			

	centralized plants			
	Landfills with biogas valorisation			
GERMANY	Sewage sludge	Electricity	40970GWh/year	26650GWh/year
	Biowaste	Heat		
	Agriculture	Vehicle fuel		
	Industrial	Flare		
	landfills			
REPUBLIC OF IRELAND	Sewage sludge	Data not provided	Data not provided	Data not provided
	Biowaste			
	Agriculture			
	Industrial			
	Landfills			
NORWAY	Sewage sludge	Electricity	500GWh/year	18% of 500GWh
	Biowaste	Heat		
	Agriculture	Vehicle fuel		
	Industrial	Flare		
	landfills			
REPUBLIC OF KOREA	Sewage sludge	Electricity	1925GWh/year	479GWh/year, 27%
	Biowaste	Heat		
	Agriculture	Vehicle fuel		
	Industrial	Flare		
	Landfills	Biogas scale		
SWEDEN	Sewage sludge	Heat	1589GWh/year	415GWh/year
	Biowaste	Vehicle fuel		
	Agriculture	Flare		
	Industrial			
	landfills			
SWITZERLAND	Sewage sludge	Heat	1023GWh/year	258GWh/year, 24% of total

	Biowaste	Vehicle fuel		
	Agriculture	Flare		
	Industrial wastewater			
NETHERLANDS	Sewage sludge	Electricity (60%)	12530GWh/year	219MW
	Biowaste	Biogas(30%)		
	Agriculture	Heat(10%)		
	Industrial wastewater			
UNITED KINGDOM IS	Sewage sludge	Electricity production	10494GWh/year	Data not provided
	Biowaste			
	Agriculture			
	Landfills			
	Industrial			
	MSW			

Table 2.1: Comparison of annual biogas production between different countries

2.2.2 Conclusion of the comparison of Annual Biogas production in 13 different countries

Biogas generation, Except for Germany, no other member country has more than 1000 biogas plants now, and only the United Kingdom has more than 500, according to available data. In most nations, 0.5-2 TWh of biogas is generated annually, with the exception of the United Kingdom and Germany, where production is many times higher. In 2012, 10 TWh of energy (mostly electricity) was created from biogas in the United Kingdom; while 40 TWh of energy was generated in Germany (mainly electricity).In most nations, the biogas produced is primarily used to generate heat and power.Many countries, including Denmark, Germany, and South Korea, have taken steps and expressed an interest in expanding the use of biogas as a car fuel in the near future [2]. Financial assistance schemes vary greatly from country to country. There are several systems in place, including feed-in tariffs, investment awards, and tax exemptions. In Task 37 member nations, there is a clear link between the financial assistance structure and how biogas is used. Feed-in tariffs for electricity in the UK and Germany have led to the majority of biogas being used to generate energy, whilst Sweden's tax-free system encourages the use of biogas as a car fuel[2].

2.2.3 Why Germany is the leading producer of Biogas in this comparison

Two-thirds of Europe's biogas plant capacity is located in Germany. An important raw material for the development of Germany's biogas sector and for government policy is energy crops. The primary reason for this is that maize is the primary grain used in the production of energy crops for biogas. Anaerobic digestion may be improved using a brand-new reactor system. The use of newer, more efficient technology that generates both heat and electricity. Crop leftovers, continuous harvests, animal waste, and landfill methane recovery have lately been included into policy. There are new methods being investigated for upgrading biogas and converting it to hydrogen in the anaerobic digestion process now. [2].

2.2.4 Biogas demand globally for direct use in the Stated PoliciesScenario(2018-2040)

By the year 2040, biogas production will get increased on a high scale and this biogas will be used directly. To meet the increasing demands of the growing population fossil fuel will almost get finished by that time, so biogas will come as a fuel that can be directly used. In figure 2.1, biogas demand for direct use globally can be observed. By the year 2040 different countries like India, China, and Africa are showing a gradual increase in the direct use of biogas.

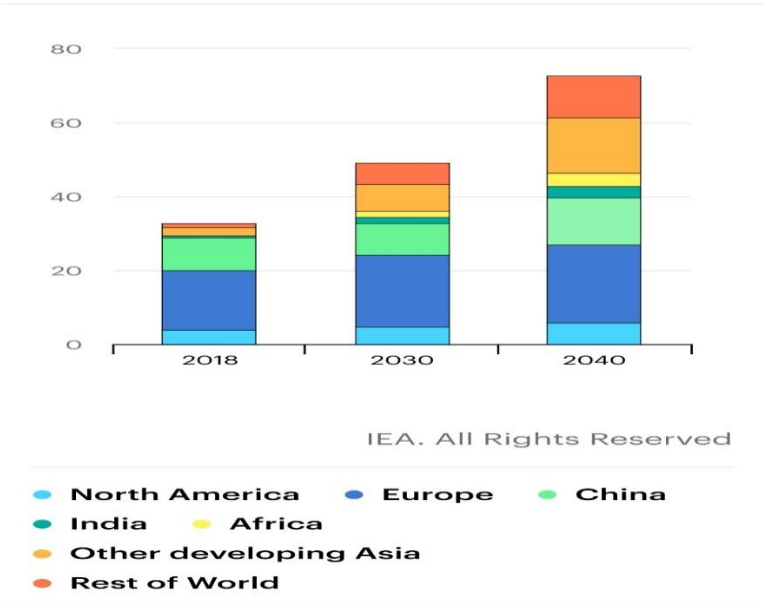

Figure 2.1) Graphical representation of different countries showing direct use of biogas

2.2.5 Biogas production by Region and Feedstock type

The development of biogas depends not only on the availability of raw materials, but also on strategies to promote their production and use, and the composition of biogas depends on the type of raw material and is therefore non-uniform throughout the world. Different countries use different types of raw materials for biogas production, depending on the availability of raw materials. Crop, animal manure, urban solid waste, and waste generated from urban sewage are the main types of raw materials used in different countries. Figure 2.2 shows different raw materials used in different countries..

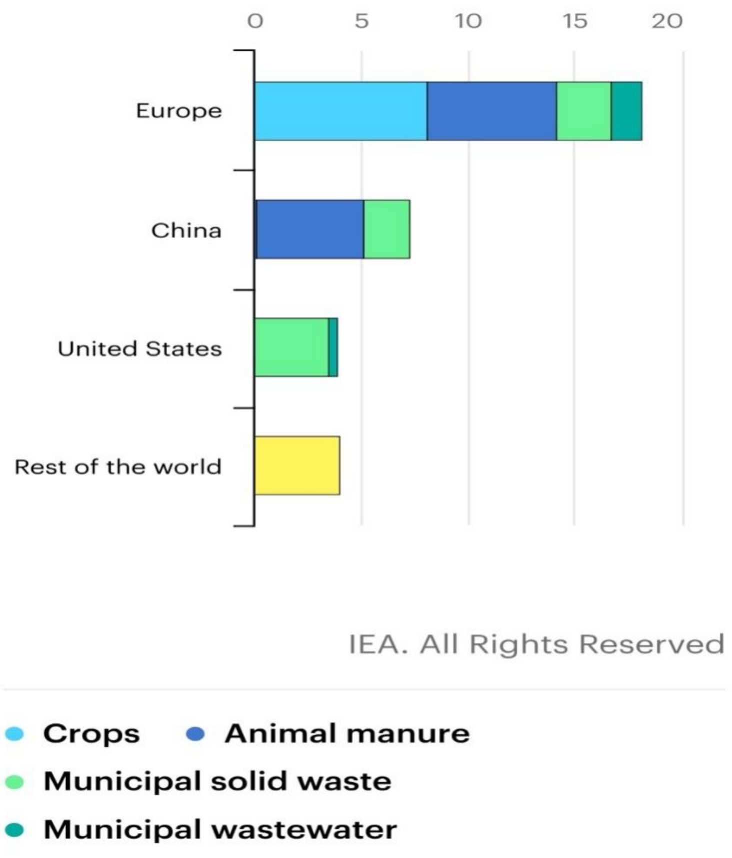

Figure 2.2: Biogas production by Region and Feedstock type

Chapter -3

STUDY OF THE MUNICIPAL SOLID WASTE GENERATED IN DELHI CITY

3.1 Introduction

Mismanagement of municipal solid waste (MSW) has now become one of the most serious national challenges, as it compromises the environment's purity and cleanliness. Squander from households, non-dangerous strong waste from mechanical, business, and institutional foundations, market garbage, yard waste, agricultural wastes, and street sweepings are all included in municipal solid waste (MSW). Developing urbanisation in India will result in a massive increase in garbage over the next two decades[12].

3.2 Data Analysis

Data was collected from the authentic site CPCB (Central Pollution Control Board).It has been mentioned in the report that there are Urban Local Bodies present in Delhi.

There are total 5 urban local bodies in Delhi, there are total 280 wards and population of 280 wards and the waste generated is 10817 TPD (Tonnes Per Day)out of which 10614 TPD is collected ,5714 TPD is processed and 5225 is land filled.In figure 4.1) Data about different ULB with no. of wards present is given[15],[12].

1.North Delhi Municipal Corporation

2.South Delhi Municipal Corporation

3.East Delhi Municipal Corporation

4.New Delhi Municipal Corporation

5.Delhi Cantonment Board

URBAN LOCAL BODY	NO. OF WARDS
North DMC	104
SDMC	104
EDMC	64
DCB	08
NDMC	14

Table 3.1: Urban local body with number of wards present in them

Every single day, the city generates more than 9,500 tons of waste via its normal operations (TPD). More than 8,000 tons per day's worth of trash is processed by the disposal facilities located at Bhalswa, Okhla, and Ghazipur combined. If the informal sector were responsible for managing the bulk of the debris, the amount of trash that is really generated in the city may be far higher. It is estimated that there are around 150,000 persons in Delhi involved in the activity of rag picking. As a notion, waste-to-energy has been promoted to city governments as a magic bullet. Burn it all down and forget about it. That, however, is not the case. Residents of SukhdevVihar are well aware of the plight of a WTE facility located adjacent to their homes.[12].The collection and segregation of waste take place in these 5 Urban Local Bodies: 90% in the civil area is collected by NDMC, 60% from the army area is collected by Delhi Cantonment Board, EDMC collects 100% in 3 Model Wards, 75% in 6 wards and 30% in 55 wards. 80% of waste is collected in 3 Model wards by North DMC.SDMC collects about 80%in 13 wards (including 3 model wards)[12]. In figure 4.2) the types of the urban local body and how much amount of waste they segregate is given.

URBAN LOCAL BODIES	AMOUNT
NDMC	90%
DCB	90% in Civil Area & 60% in the Army Area
EDMC	100% in 3 Model Wards, 75% in 6 Wards & 30% in 55 Wards
NORTH DMC	80% in 3 Model Wards
SDMC	About 80% in 13 Wards. (Including 03 Model Wards)

Table 3.2: Urban local bodies with the amount of waste segregated

3.2.1 Amount of waste generated in different Urban Local Bodies

North DMC generates 4500 tonnes per day of Municipal waste and the amount of waste processed in tonnes per day is 2400 TPD near about 53%. SDMC generates 3600 tonnes per day of Municipal Solid Waste out of which 1850 TPD about 51% gets processed. EDMC produces 2700 TPD municipal solid waste and the amount of waste processed is 700 TPD (26%).NDMC produces 272 Tonnes per day of waste out of which 272 TPD gets processed which means 100% of the waste produced in New Delhi Municipal Corporation gets processed. Delhi Cantonment Board produces about 72 tonnes per day of waste out of which 51% is 37 tonnes per day of waste gets processed. So the total waste production is 11144

Tonnes Per Day out of which 5259 that is 47% get processed [12]. In figure 4.3 we can see how much amount of waste is generated and how much is being processed.

ULB	Total MSW Generation in TPD	Total MSW being Processed in TPD
North DMC	4500	2400 (53%)
SDMC	3600	1850(51%)
EDMC	2700	700(26%)
NDMC	272	272(100%)
DCB	72	37(51%)
TOTAL	11144	5259 (47%)

Table 3.3: MSW generation in different Urban Local Body

3.2.2 Strategies for managing waste

Not only various metro cities/towns/states, but typically the entire country of India is suffering from poor MSW management, and one of the main reasons is inappropriate source segregation and low community engagement. Otherwise, it is not difficult work, but it now appears unattainable. Along with community participation, there is a chronic lack of communication between ULBs and the community. Every trash generator now has the responsibility of segregating and storing waste in distinct bins, such as biodegradable, non-biodegradable, and home hazardous waste, before passing it on to the collection authorities. As a result, every trash generator will be responsible for sorting their waste, while the respective municipality would be responsible for door-to-door pickup. Waste collection from residences and communal bins must also be done in a separate manner. It must be ensured that waste is properly covered and does not spill during transportation.

3.3 Findings from the data

1. There are Total of 5 Compost plants of 1 TPD each and 4 Bio Methanationplants of 5 TPD each proposed to be developed in Delhi.

2. Biodegradable waste can be segregated and can be used as a biofuel for the production of biogas/ biomethane.

- NORTH DMC

(i) Accelerated Composter / Bio-Methanisation Plant 1 TPD Capacity (6 Nos)

(ii) Bio-Methanation Plants 5-TPD Capacity (4 Nos)

- EAST DMC

(i) Composters of 1 TPD Capacity (10 Nos)

(ii) Bio-Methanation Plants 5-TPD Capacity

- SOUTH DMC

(i) Four Compost Plants of 1 TPD each

(ii) Four Bio-Methanation Plants (5 TPD Each)

3.4 Summary

It is essential to use a variety of tactics. A landfill is a need, but it should only be used for inert trash and rejects. We need waste-to-energy facilities, but they only work with things that have already been sorted. Wet garbage that has been separated offers good composting or biogas production potential since it contains over 50% biodegradable waste. Until we can discriminate at the basic level, none of this will work. In order to save money, it's necessary to think creatively about how we might gather and convey the millions of rupees we've already spent. We may learn from our Indian neighbours' cities, which are known for their excellent trash management.[12]. There are various problems related to the Municipal Solid Waste Generated in Delhi like the dustbins and dhalaos are not being cleared on a regular basis due to which people started throwing waste here and there, second problem is thatproper maintenance of dhalaos, dustbins, and waste storage points is not done regularly and there is lack of financial resources[14]. The number of regular operators required is more but there are not enough number of workers than required, the requirement is temporarily fulfilled by staff peronnel. There are 3 operational landfill sites in Delhi which are Bhalaswa, Ghazipur, and Okhla, they have almost exhausted their capacity for waste disposal. But continuous waste is getting disposed of in these open dumping sites. The next problem is the vehicles are not properly maintained which are used to transport waste from one place to other and the reason behind this is inadequate workshop facilities and the maintenance procedures, this problem has to lead to a breakdown on a frequent basis of the vehicles being used, they get out of service for a long duration of time [12]. At each stage of waste collection and disposal, different actors are involved. The garbage collector (contracted out or chosen by the Residents' Welfare Association [RWA] or the Urban Local Body [ULB) collects the waste created at home and deposits it at the dhalao (community bin)[15]. The garbage from these dhalaos is subsequently collected by the ULB. The institutions involved in garbage management are depicted in the diagram below. Ragpickers from the dhalaos rescue recyclables before the rubbish is collected.Recycling is not dirty, and compost created from organic matter is of higher quality, thanks to source separation. Furthermore, distributed composting of organic materials reduces transportation costs. As a result, putting the responsibility for waste separation on waste generators is the first step toward waste management efficiency[14].Currently, households offer kabadiwalas rubbish such as old newspapers and discarded glass bottles (scrap dealer). However, the garbage that is generated on a daily basis is not separated. Ragpickers collect milk packets and packaging materials from everyday rubbish to be recycled at the dhalao level. In order to arrive at the best solution, it's critical to understand the roles of the people involved at each stage [12].

Chapter-4

Upgradation of biogas

4.1 Introduction

Biogas is an energy source made from biodegradable / organic waste. Biogas production is an environmentally friendly and cost-effective alternative to waste. It has the potential to meet the energy needs of rural areas and counteract the effects of reckless burning of biomass resources. Another advantage of biogas is that the fertilizer produced can be dried and sold as high quality compost [4]. Wastes of varying quality and quantity, eg B. Animal manure, agricultural waste, solid foods, municipal wastes are available in rural and urban areas. This waste can be used for both large and small scale biogas production. Biogas is composed of many gases such as oxygen, hydrogen sulfide, and carbon dioxide. These other gases reduce the efficiency of biogas [3]. When processing biogas, methane concentration can increase by up to 90%. The upgraded biogas can be used as a vehicle fuel alternative to the vehicle [2]. There are several ways to upgrade biogas, but you should choose a cheaper and more efficient one. Therefore, we have adopted a simple and inexpensive cleaning technology. There are several ways to upgrade biogas and use it as an alternative energy source and fuel.The main methods which are used for upgrading Biogas are as follows:

1. Water absorption
2. Polyethylene glycol absorption
3. Carbon molecular sieves
4. Membrane separation

   The method which we are using for our experiment is Water Scrubbing [11].

   Water Scrubbing:Water scrubbing is the process of removing carbon dioxide, hydrogen sulphide, and other balanced gases from biogas. This is because these gases are more soluble in water than methane. The absorption process is physical and economical. In this process, biogas is pressurized and fed to the bottom of the filled column, adding water to the top [4]. Table 4.1 below shows a comparison of raw and upgraded biogas..

4.1.1 Comparison between Raw Biogas and Upgraded Biogas

RAW BIOGAS	UPGRADED BIOGAS
Methane percentage (55-65%) and carbon dioxide is (35-45%).	**Methane present is at more than 90 % and carbon dioxide decreased to less than 10%.**
Mode of utilization: nearbyor on-site, used for cooking or electricity purpose.	**Upgraded biogas can be used as a vehicle fuel and has remote applications.**
The presence of carbon dioxide besides being non-combustible restrains its compressibility thereby making biogas difficult to be stored in containers.	**The concentration of carbon dioxide is less than 10 percent so compressing and transporting upgraded biogas is easy.**
For utilization at far-off places, it must be stored in biogas balloons and taken to the site of utilization or it can be transported by pipelines.	**Upgrading, compression, and bottling facilities easy storage and transportation asa vehicle fuel, cooking fuel, and for electricity production.**

Table 4.1: Comparison between Raw biogas and Upgraded biogas

4.2 Experimental setup

Different types of materials are used in upgrading Biogas. Upgraded Biogas has many benefits as compared to raw biogas. Upgraded biogas can be directly used as a vehicle fuel. So we tried to increase the efficiency of biogas by reducing the$C0_2$ and increasing the methane concentration. We used scrubbing technique for upgrading Biogas here. Materials which have the potential to increase the solubility of gases inside water and decrease gases like CO_2,H_2S and other balance gases were used.

4.3 Material and methods

4.3.1 NaOH (Sodium hydroxide)

4.3.2 Pine Needles

4.3.3 Wood ash

4.3.4 Algae substrate

4.3.5 Soil

4.3.6 Water

4.3.6 Biogas analyser

4.3.7 Reagent bottles

4.3.7 Thermometer

4.3.8 Flexible plastic pipes

4.3.9 Biogas digester

Method: water based scrubbing technique as standard method was used.Water scrubbing is the process of removing carbon dioxide, hydrogen sulphide, and other balanced gases from biogas. This is because these gases are more soluble in water than methane. The absorption process is physical and economical. In this process, biogas is pressurized and fed to the bottom of the filled column, adding water to the top

EXPERIMENTAL WORK

AIM 1: Treatment of Biogas to enhance the methane concentration by reducing the carbon dioxide.

4.3.10 **Treatment of Biogas by NaOH**:Biogas produced is passed through 1% NaOH in 1000 ml water for 60 seconds.

Process: We have mixed 1% NaOH in 1000ml of water properly.then we have taken a gas analyzer in which 2 pipes are connected one to the reagent bottle containing this solution through which biogas is going to passed and other to the biogas digester. We turn on the button present on the biogas analyzer and this machine note down all the reading of the gases present in the biogas. Firstly we take the control readings where the exact amount of gases present in the digester is given. After that we pass this biogas through this solution.

TABLE 4.2: There is a 15% increase in Methane and a 12% decrease in Carbon dioxide concentration

GASES	Control reading	After treatment reading
CH_4	55.2%	69.2%
CO_2	40.3%	28.5%
O_2	0.1%	0.3%
H_2S	660ppm	7ppm
Balance gases	4.5%	2.0%

4.4.2 Treatment of Biogas through pine needles:

Pine Needles are taken (10g in 1000 ml water)in a reagent bottle. control reading from the digester is noted of the biogas, then biogas is passed through this solution and the results are recorded after 60 seconds. Pine needles do not show any significant result in increasing the biogas efficiency or Methane concentration by absorbing carbon dioxide. In table 4.3 we can check if there is any change in gases concentration or not.

Table 4.3 There is no significant change in methane and carbon dioxide concentration.

GASES	Control Reading	After treatment reading
CH_4	68.4%	68.9%
CO_2	26.6%	25.4%
O_2	0.0%	0.3%
H_2S	9ppm	8ppm
Balance gases	4.5%	5.4%

4.4.3 Treatment of Biogas by wood ash: Biogas is passed through 10g wood ash (biomass) in 1000ml for 60 seconds.[1] A solution is prepared in 1000 ml where 10g of wood ash is mixed with 1000ml of water. Control readings of the biogas were recorded then biogas is passed through this solution. After that we observe if any change is there or not in the readings taken before and after treatment. As we can see in table 4.4 no significant change is observed.

Table 4.4 There is no significant change in gases

GASES	Control Reading	After treatment reading
CH_4	77.3%	78%
CO_2	19.5%	16.7%
O_2	0.5%	0.3%
H_2S	6ppm	11ppm
Balance gases	2.7%	5.3%

4.4.4 Treatment of Biogas by Algae: Biogas is passed through algae which is converted into substrate by grinding it and taking 10g of this substrate in 1000ml water.Algae have the property of filteration or absorbing carbon dioxide from the atmosphere. So a test is performed by making algal substrate and from that 10g is dissolved in 1000ml of water. Control readings were recorded then biogas is passed through this solution. In table 4.5 we can observe the change in readings.

Table 4.5 There is no significant change appeared in the gases.

Gases	Control Reading	After treatment Reading
CH_4	77.3%	77.5%
CO_2	19.5%	17.2%
O_2	0.5%	0.3%
H_2S	6ppm	10ppm
Balance gases	2.7%	4.6%

Figure 4.1: In this picture biogas is passed through algae substrate.

4.4.5 Treatment of Biogas by soil: biogas is passed through 10g soil in 1000ml water.10g of soil is taken in 1000ml of water. We have taken to check the presence of carbon dioxide absorbing microbes. A solution was prepared where 10g of soil is mixed with 1000ml of water and biogas is passed through it to check if it has the possibility of increasing methane and decrease the amount of carbon dioxide present. As in table 4.6 there is 2 % increase in CH_4.

Table 4.6 There is 2 % increase in methane gas and 2 % reduction in carbon dioxide

Gases	Control Reading	After treatment reading
CH_4	77.3%	79%
CO_2	19.5%	16.8%
O_2	0.5%	0.2%
H_2S	6ppm	12ppm
Balance gases	2.7%	5.0%

Aim 2: **Treatment of Biogas to enhance the methane concentration by reducing the carbon dioxide by water scrubbing method**.

Method: In this experiment, we took water at different temperatures and at different concentrations, and after that biogas is passed through this water. Carbon dioxide is soluble in water and its solubility decreases as temperature increases and solubility gets increased when temperature is decreased. So here we created different conditions by altering the temperature and volume of water to check the solubility of CO_2. 4 different conditions were created to check the solubility.

1. **CONDITION 1**

Temperature of water =1^0C,Time =60 seconds, Volume of water=2000ml

Table 4.7 Biogas measured at 1 degree Celsius in 1000 ml volume

GASES	CONTROL READING	READING 1	READING 2	READING 3
CH4	59.8%	63%	62.8%	62.9%
CO_2	34.7%	32.5%	32.7%	32.6%
O2	0.5%	0.2%	0.2%	0.2%
H2S	283ppm	360ppm	355ppm	338ppm
BALANCE GASES	4.9%	4.3%	4.3%	4.3%

2. **CONDITION 2**:

Temperature= 20^0C,   Time=1 minute,   Volume=2000ml

Table 4.8: Biogas measured at 20 degrees Celsius in 2000ml

GASES	CONTROL READING	READING 1	READING 2	READING 3
CH4	59.8%	61.8%	61.7%	61.7%
CO_2	34.7%	33.2%	33.4%	33.2%
O2	0.5%	0.2%	0.1%	0.1%
H2S	283ppm	377ppm	369ppm	340ppm
BALANCE GASES	4.9%	4.8%	4.9%	5.0%

3. **CONDITION 3**:

Temperature= 1, Time= 1minute, Volume=1000ml

Table 4.9: biogas measured at 1 Degree Celsius in 1000ml of water

GASES	CONTROL READING	READING 1	READING 2	READING 3
CH4	59.8%	61.6%	61.6%	61.5%
CO_2	34.7%	33.3%	33.2%	33.3%
O2	0.5%	0.1%	0.1%	0.1%
H2S	283ppm	401ppm	384ppm	390ppm
BALANCE GASES	4.9%	5.2%	5.1%	5.1%

4. **CONDITION 4**:

Temperature= 20^0C, time =1 minute, volume= 1000ml

Table 4.10: Biogas measured at 20 degrees in 1000 ml of water.

GASES	CONTROL READING	READING 1	READING 2	READING 3
CH4	59.8%	62%	61.3%	61.5%
CO_2	34.7%	33.5%	33.2%	33.3%
O2	0.5%	0.1%	0.1%	0.1%
H2S	283ppm	401ppm	384ppm	390ppm
BALANCE GASES	4.9%	5.2%	5.1%	5.1%

Chapter 5 – Results and Discussion

We have observed that NaOH has given required results where the concentration of methane gets increased upto 17% and carbon dioxide gets decreased to 12%. While passing biogas through different components like soil 0.7% increase in methane gas & 2.7% decrease in CO_2 is observed .In algae,0.1 % increase in methane and 1.6% decrease in CO_2 is observed. While testing with Pine Needles 0.5% of methane gets increased and 1.2% CO_2getsdecreased andinwood ash 0.4% increase in methane gas took place and 2.8% decrease in $CO_2$is observed. There is no significant increase in methane concentration and no decrease in carbon dioxide concentration observed in components like soil, algae, wood ash but NaOH gave us effective results.

We passed biogas through water in different concentrations at different temperature. As we know solubility of CO_2can be increased by lowering the temperature. We observed that methane highest concentration is observed in 2000ml of water at 1^0C for 1 minute. When it is taken at room temperature at different concentration the methane concentration remains same. So if we lower the temperature below 1^0C we can have results where Biogas can be upgraded by water scrubbing effectively.

Sodium hydroxide has increased the solubility of carbon dioxide to dissolve in water, which resulted in higher methane concentration and low carbon dioxide concentration.In experiment 2, solubility of carbon increases when we decrease the temperature so when we took 2000ml water at 1^0C for 1 minute, at that point we obtained the maximum methane concentration.
If we increase the concentration of NaOH in water, then concentration of methane will get increased gradually when we pass biogas through NaOH. By this process we can upgrade biogas at very low cost. Upgrading Biogas is not an easy task it's a long process but if we opt for water based scrubbing technique then it will take less time and will be more economical. Lowering the temperature of water can increase the solubility of carbon dioxide in water , in the experiment performed temperature is 1^0C, but if we lower the temperature there are chances that without using any chemical , concentration of biogas can be increased and carbon dioxide and other gases can be decreased.

Conclusion

We can conclude that biogas upgradation can be performed by using simple techniques like water scrubbing, which is a low cost method. Using NaOH at higher concentration can give us good results. Water at low temperature has the potential to increase the efficiency of biogas by decreasing gases like carbon dioxide and oxygen.

After doing research on the city of Delhi, we came to the conclusion that hybrid approaches are required. A landfill is the appropriate location for disposing of inert and rejected items. WTE plants are essential, but in order to function properly, they must only employ material that has been sorted and cleaned beforehand. Because more than half of the wet waste may be broken down into biodegradable components, composting and the production of biogas are both viable options. In addition, none of this will be effective unless the underlying factors that are causing this are identified and addressed. In order to avoid spending billions of dollars on collection and transportation, creative alternatives are required. The number of regular operators required is more but there are not enough number of workers than required, the requirement is temporarily fulfilled by staff personnel so number of people employed in biogas sector should be more to take care of all the operations going on. There are 3 operational landfill sites in Delhi which are Bhalaswa, Ghazipur, and Okhla; they have almost exhausted their capacity for waste disposal. But continuous waste is getting disposed of in these open dumping sites so proper check should be done and more dumping sites should be created if land is available. The next problem is the vehicles are not properly maintained which are used to transport waste from one place to other and the reason behind this is inadequate workshop facilities and the maintenance procedures, this problem has to lead to a breakdown on a frequent basis of the vehicles being used, they get out of service for a long duration of time [12]. Proper checking of transportation should be done and no of vehicles used should be more in number. In order to arrive at the best solution, its important for people to understand the roles of the people involved at each stage [12].

REFERENCES

[1]M. Fernández-Delgado Juárez *et al.*, “Biogas purification with biomass ash,” *Waste Manag.*, vol. 71, pp. 224–232, Jan. 2018, doi: 10.1016/j.wasman.2017.09.043.

[2]“The outlook for biogas and biomethane to 2040 – Outlook for biogas and biomethane: Prospects for organic growth – Analysis,” *IEA.* https://www.iea.org/reports/outlook-for-biogas-and-biomethane-prospects-for-organic-growth/the-outlook-for-biogas-and-biomethane-to-2040 (accessed May 14, 2022).

[3] “An introduction to biogas and biomethane – Outlook for biogas and biomethane: Prospects for organic growth – Analysis,” *IEA.* https://www.iea.org/reports/outlook-for-biogas-and-biomethane-prospects-for-organic-growth/an-introduction-to-biogas-and-biomethane (accessed May 14, 2022).

[4]R. Joshi and S. Ahmed, “Status and challenges of municipal solid waste management in India: A review,” Cogent Environ. Sci., vol. 2, no. 1, p. 1139434, Dec. 2016, doi: 10.1080/23311843.2016.1139434.

[5] K. N. Kumar and S. Goel, “Characterization of Municipal Solid Waste (MSW) and a proposed management plan for Kharagpur, West Bengal, India,” Resour. Conserv. Recycl., vol. 53, no. 3, pp. 166–174, Jan. 2009, doi: 10.1016/j.resconrec.2008.11.004.

[6]CPCB, “The National Action Plan for Municipal Solid Waste Management,” 2015. http://cpcb.nic.in/national-action-plan/ (accessed May 21, 2019).

[7] CPCB, “Annual Report,” CPCB, 2015. [Online]. Available: https://cpcb.nic.in/uploads/MSW/MSW_AnnualReport_2014-15.pdf.

[8] CPHEEO, “COMPOSITION AND QUANTITY OF SOLID WASTE.” CPHEEO, Accessed:Jan.01,2020.[Online].Available: http://cpheeo.gov.in/upload/uploadfiles/files/chap3.pdf

[9] “Status of biogas production and biogas upgrading: A global scenario,” Emerging Technologies and Biological Systems for Biogas Upgrading, pp. 3–26, Jan. 2021, doi: 10.1016/B978-0-12-822808-1.00002-7.

[10] P. Weiland, “Biogas production: current state and perspectives,” Applied Microbiology and Biotechnology, vol. 85, no. 4, pp. 849–860, Sep. 2009, doi: 10.1007/s00253-009-2246-7.

[11]SeminarLinks,“BiogasPPT,”Nov.06,2015. https://www.slideshare.net/asertseminar/biogas-ppt (accessed May 14, 2022).

[12] N. Srivastava, A. K. Shrivastav, M. Srivastava, and P. K. Mishra, “Chapter 22 - Biofuels production using wheat straw,” ScienceDirect, Jan. 01, 2020.

[13] vigyanashram, “Bio-Gas,” Dec. 03, 2012. https://www.slideshare.nepsidjain, “Bio gas,” Jan. 10, 2014. https://www.slideshare.net/psidjain/bio-gas-29872180 t/vigyanashram/biogas-15459722

[14]psidjain, “Bio gas,” Jan. 10, 2014. https://www.slideshare.net/psidjain/bio-gas-29872180

[15]PubChem,“Methane,” Nih.gov,2019. https://pubchem.ncbi.nlm.nih.gov/compound/Methane

[16]BiogasCleaningandUpgradingTechnologies,” ohioline.osu.edu.https://ohioline.osu.edu/factsheet/AEX-653.1-14

[17] CPCB, ‘’Status of municipal solid waste generation, collection treatment and disposal in class-i cities’’,vol. 8, pp.123-129, 2020.

[18] A. Singh, G. Gupta, and A. Singh, “Quantitative and Qualitative Characterization of Solid Waste Generated in Chitrakoot (India) and Its Management: A Comparative Study of Karwi and Chitrakoot Nagar Panchayat,” Journal of Environmental Science & Engineering, vol. 56, no. 1, pp. 115–122, Jan. 2014, Accessed: May 14, 2022.

[19] S. Sumithra, V. Sunitha, and G. Nagaraju, “Municipal Solid Waste Management in Kadapa Town: A Case Study,” Journal of Environmental Science & Engineering, vol. 56, no. 1, pp. 123–126, Jan. 2014, Accessed: May 14, 2022.

[20] S. Kumar, H. Dhar, V. V. Nair, J. K. Bhattacharyya, A. N. Vaidya, and A. B. Akolkar, “Characterization of municipal solid waste in high-altitude sub-tropical regions,” Environmental Technology, vol. 37, no. 20, pp. 2627–2637, Mar. 2016, doi: 10.1080/09593330.2016.1158322.

[21] L. Sekhohola-Dlamini and M. Tekere, “Microbiology of municipal solid waste landfills: a review of microbial dynamics and ecological influences in waste bioprocessing,” Biodegradation, Sep. 2019, doi: 10.1007/s10532-019-09890-x.

[22]M. Sharholy, K. Ahmad, G. Mahmood, and R. C. Trivedi, “Municipal solid waste management in Indian cities – A review,” Waste Manag., vol. 28, no. 2, pp. 459–467, Jan. 2008, doi: 10.1016/j.wasman.2007.02.008.

[23] B. Gupta and S. K. Arora, “Municipal solid waste management in Delhi—The Capital of India,” IJIRSET, vol. 54, no. 4, pp. 5130–5138, 2016.

[24]N. Gupta, K. K. Yadav, and V. Kumar, “A review on current status of municipal solid waste management in India,” J. Environ. Sci., vol. 37, pp. 206–217, Nov. 2015, doi: 10.1016/j.jes.2015.01.034.

[25] R. K. Kaushal, G. K. Varghese, and M. Chabukdhara, “Municipal solid waste management in India—Current state and future challenges: A review,” Int. J. Eng. Sci. Technol, vol. 4, no. 4, pp. 1473–1479, 2012.

[26] S. Sahu, S. J. Nair, and Sharma P. K., “Review on solid waste management practice in India: A state of art,” Int. J. Innov. Res. Dev, vol. 3, no. 3, pp. 261–264.

[27] V. Upadhyay, A. S. Jethoo, and M. P. Poonia, “Solid waste collection and segregation: A case study of MNIT campus, Jaipur,” Int. J. Eng. Innov. Technol., vol. 1, no. 3, 2012.

[28] M. Aljaradin and K. M. Persson, “Comparison of Different Waste Management Technologies and Climate Change Effect—Jordan,” Am. J. Clim. Change, vol. 1, no. 2, pp. 57–63, Jun. 2012, doi: 10.4236/ajcc.2012.12006.

[29]D. C. Wilson, L. Rodic, A. Scheinberg, C. A. Velis, and G. Alabaster, “Comparative analysis of solid waste management in 20 cities:,” Waste Manag. Res., Mar. 2012, doi: 10.1177/0734242X12437569. [30] CPCB (Central Pollution Control Board)., “Central pollution control board (CPCB) bulletin, Government of India.” CPCB (Central Pollution Control Board)., 2016, Accessed: Jun. 13, 2020.

[30]D. Vij, “Urbanization and Solid Waste Management in India: Present Practices and Future Challenges,” Procedia - Soc. Behav. Sci., vol. 37, pp. 437–447, Jan. 2012, doi: 10.1016/j.sbspro.2012.03.309.

[31] CPCB, “Annual Report,” CPCB, 2019. [Online]. Available: https://cpcb.nic.in/uploads/MSW/MSW_AnnualReport_2018-19.pdf.

[32]K. A. Kalyani and K. K. Pandey, “Waste to energy status in India: A short review,” Renew. Sustain. Energy Rev., vol. 31, pp. 113–120, Mar. 2014, doi: 10.1016/j.rser.2013.11.020.

[33] Sharma and Jain, “Overview of Municipal Solid Waste Generation, Composition, and Management in India,” J. Environ. Eng., vol. 145, no. 3, p. 04018143, Mar. 2019, doi: 10.1061/(ASCE)EE.1943-7870.0001490.

[34] MNRE (Ministry of New and Renewable Energy), “Power generation from municipal solid waste,” 2016. Accessed: Feb. 13, 2019. [Online]. Available: http://164.100.47.193/lsscommittee/Energy/16_Energy_20.pdf