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A Survey on Air Pollution and Its Prevention through Biogas Technology

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ABSTRACT: The first section of the paper explores the impact of manmade industries and automobiles on the atmosphere over past couple of centuries. The shift in the basic energy source from biomass to coal and other fossil fuel which lead to the industrial revolution and an unprecedented increase in the amount of greenhouse gases. Additionally, the text explores the main causes and effects of air pollution and the different methods for its prevention including wind turbines, solar panels, bio fuels and biogas. Next we discuss about the viability of the biogas technology, its contents and methods of production. The principle of anaerobic digestion and the four steps involved in the production of biogas(Hydrolysis , Acidogenesis, Acetogenesis and methanogenesis). Furthermore we discuss about the different uses for this technology and its advantages. At last we find out how the biogas technology, if implied in large scale, can help us cope with the current issue of air pollution along with solving several other environmental issues.

I.INTRODUCTION

The world has seen a massive increase in the number of industries and automobile vehicles in the wake of industrial revolution during 20th century. This change can be attributed to the ground breaking advancement in science and technology. Until the 19th century, the energy basis of human society had been biomass energy, mainly the burning of wood to produce heat. With the modern revolution the world entered the age of coal and steam power. The fossil fuel era had begun, and this is the era we still live in today. By the early 19th century, the harnessing of steam power enabled humans to vastly multiply the energy generated from burning coal, thereby greatly expanding the amount of energy available to humans per capita, that is, to each individual. By 1914, petroleum, a second major fossil fuel, began to be extensively used as well[1]. The unprecedented rise in the world population accompanied the fossil fuel revolution. During the 1800s the world population was about 900 million by 1914 it increased two folds and soon people started exploiting the natural resources tremendously. Once people realised the potential of fossil fuels there was no looking back, more and more people started shifting towards the cities for better job opportunities as more and more industries were set up. Air pollution has existed for centuries but it became significant only after 20th century, when people started to exploit the natural resources. Most of the environmental problems that we face today are because of the excessive use of the fossil fuels[2]. Burning of fossil fuels releases a number of pollutants that contributes in the air pollution, acid rain, Global warming etc. The problem of Pollution and depleting natural resources is becoming more severe by day and unless we take the essential steps to shift our inclination to the non-renewable resources to renewable resources we might have to face the consequences not much farther in the future[3].

II.RELATED WORK

Increasing pollution causes global warming which affects the ecosystem by depleting the ozone. Depletion of ozone causes harmful rays to penetrate into the earth's atmosphere thereby disturbing the balancing of the ecosystem. Various researchers have been working on the different alternatives in reducing the global warming and one of the best alternatives is biogas. Biogas consists of Methane which is a cancer causing agent to the atmosphere and results in global warming. Utilizing biogas gives energy and also maintains the balance of the ecosystem. Methane has the

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capability to absorb more energy and retain for a long time[4]. So reducing the percentage in the atmosphere results in cooling of earth's surface and also prevents the harmful rays into the earth's surface.

III.POLLUTANT GASES

Air pollution is one of the major factors in the deterioration of the atmosphere. Introduction of different particulates and pollutants are responsible for the death and damage to all the living organisms on the plant[5]. Before the industrial revolution the main source of air pollution were volcanoes, wild fire and burning of biomass but since the advent of fossil fuels there has been a huge spike in the percentage concentration of the pollutants in the atmosphere[6]. The main by-products of burning fossil fuels are as follows.

- Carbon Monoxide
- Carbon Dioxide
- Sulphur Dioxide
- Nitrogen Oxide
- Lead
- Particulate M

IV.CAUSES OF AIR POLLUTION

Air pollution is caused by both human and natural reasons. Natural causes of air pollution include volcanic activity, wind erosions, forest fires, natural radioactivity etc. Air pollution had existed long before the modernization of society but it became significant only after the discovery of fossil fuels. Following are the main reasons for air pollution.

Industrial emissions
Burning fossil fuels

V.EFFECTS OF AIR POLLUTION

ACID RAIN

When the suspended pollutants in the air chemically react with the atmospheric moisture it creates acidic compounds. Burning of fossil fuels releases sulphur dioxide (SO₂) and nitrogen oxides (NO_x) into the atmosphere. These chemical gases react with water, oxygen, and other substances to form mild solutions of sulphuric and nitric acid. Winds spread these acidic solutions across the atmosphere. When acid rain reaches Earth, it flows across the surface in runoff water, enters water systems, and sinks into the soil[7].

GROUND LEVEL OZONE

Without ozone layer it would have been impossible for life to proliferate in this planet but when in ground layer Ozone is detrimental to human health. Chemical reactions involving nitrous oxide and VOC (Volatile Organic Compounds) in presence of sunlight create Ozone.

EFFECT ON HEALTH

Air pollution causes an array of health related problems including lung cancer, asthma, heart related problems, acute respiratory infections in children etc. People living in cities with higher air pollution index are prone to such illnesses. According to WHO reports more than 7 million people died worldwide due to air pollution.

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VI. PREVENTIVE MEASURES

Most of the electricity that we used today is produced by the burning of the fossil. By practicing activities as simple as turning off the light when not in use and adopting energy efficient method you indirectly reduce the consumption of these fossil fuels and hence decrease the amount of pollutants entering the atmosphere[1]. To shift our dependency on the fossil fuels in a large scale following alternatives should be used.

- Solar cells
- Wind turbines
- Bio fuels
- Biogas

VII. BIOGAS

Biogas is a mixture of certain gases with methane as its main component. It is combustible and can be implemented for various tasks. It can be used as cooking gas or to produce electricity. Along with that it is also very cheap, reliable and environment friendly [1-3].



Fig 1. Mini Biogas plant

Biogas is a combustible gas mainly composed of methane which can be used as cooking fuel, natural gas or to produce electricity by combustion. Looking at the trends, hike in the prices of natural fuels is inevitable in the near future[8]. Biogas can serve as a viable, eco-friendly alternative to the natural gas. In India more than 20,000 lakh cubic meters of biogas is produced every year. Maharashtra is the highest biogas producing state with yearly production of over 3500 lakh cubic meters of production[4-6].

Table1. Specific Composition of Biogas[9]

Compound	Formulae	Percentage
Methane	CH ₄	50-75
Carbon Dioxide	CO ₂	25-50
Nitrogen	N ₂	0-10
Hydrogen	H ₂	0-1
Hydrogen Sulphide	H ₂ S	0-3
Oxygen	O ₂	0-0.5

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VIII.PROCESS OF PRODUCTION OF BIOGAS

Biogas is produced by the anaerobic digestion of biodegradable materials inside a closed container. The breakdown of organic matter occurs due to the action of anaerobic bacteria, this process is known as anaerobic digestion because it occurs in the absence of oxygen, and hence the waste generated by it is odour free[9].

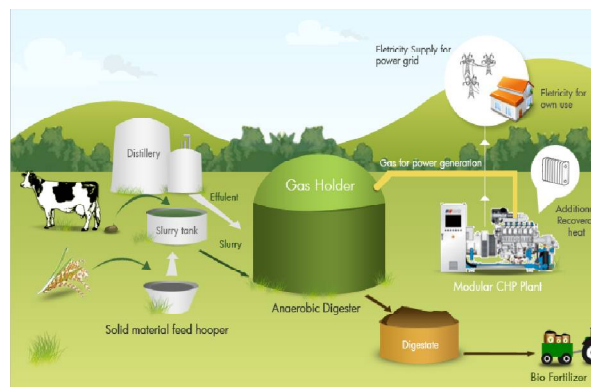


Fig 2.Cyclic process of Biogas plant[6]

IX.PRINCIPLE OF ANAEROBIC DIGESTION

Organic substances are made up of wide variety of chemical substances mainly composed of carbon and hydrogen, these elements combine with various other elements like oxygen, nitrogen, sulphur, phosphorus etc. to form organic compounds. In this process microorganisms breakdown the organic matter anaerobically into different constituents in four stages (hydrolysis, acidogenesis, acetogenesis and methanogenesis)[10]. For the production of biogas this anaerobic digestion is carried out inside sealed containers known as digesters, where the compounds undergo through various chemical reactions. These chemical reactions can be classified into four stages as follows:

X.STAGES OF ANAEROBIC DIGESTION

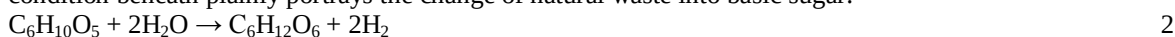
Anaerobic digestion is a process in which the bio-degradable material gets broken down by micro-organisms without the presence of oxygen. This is the frequently used process for producing biogas. There are four stages of anaerobic digestion namely Hydrolysis, Acidogenesis and Methanogenesis [3].The complete process can be illustrated by a simple chemical reaction:-



In this chemical reaction, carbon dioxide and methane were obtained as products when Glucose was digested anaerobically by the micro-organisms.

HYDROLYSIS

Mostly, large natural polymers constitute Biomass. For getting to the vitality possibilities of the substance, the microbes introduce in the digesters need to separate the extensive polymers into littler constituents. Polymers like proteins, carbohydrates and fats are transformed to amino acids, fatty acids and monosaccharides respectively [4]. The condition beneath plainly portrays the change of natural waste into basic sugar:-



So, the procedure of breaking and dissolving the expansive polymers into arrangement is called Hydrolysis. This is the main phase of anaerobic digestion.

ACIDOGENESIS

This is the second phase of anaerobic absorption in which the results of first response get changed into short chain unpredictable acids, alcohols, ketones, carbon dioxide and hydrogen by acidogenic bacteria. The items acquired in the

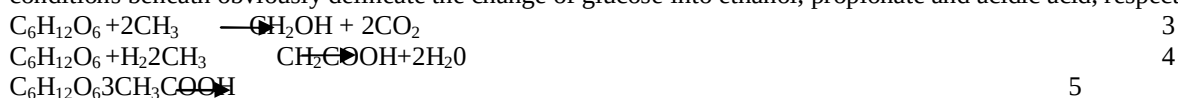
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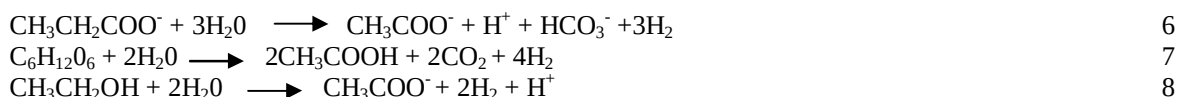
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essential acidogenesis stage are propionic acid, butyric acid, acetic acid, formic acid, lactic acid, ethanol and methanol, along with other. Out of these products, carbon dioxide, hydrogen and acidic corrosive won't experience the third phase of the digestion process [5]. They are straightforwardly used by the methanogenic microbes in the last stage. The conditions beneath obviously delineate the change of glucose into ethanol, propionate and acidic acid, respectively.



ACETOGENESIS

This is the third stage of anaerobic digestion in which the acidogenesis products like propionic acid, alcohols and butyric acid get transformed into hydrogen, carbon dioxide and acetic acid, by the acetogenic bacteria. This process will take place only if the partial pressure of hydrogen is low enough to allow the conversion of all acids thermodynamically [6]. Hence, hydrogen plays a vital intermediary role in this acetogenesis process. The equations below clearly depict the transfiguration of acidogenesis products into acetates.



METHANOGENESIS

This is the last phase of anaerobic digestion. During this stage, hydrogen and acidic corrosive shaped by the corrosive formers get changed over to methane gas and carbon dioxide by the methanogens. Methanogens are the microscopic organisms in charge of this conversion [7]. Waste adjustment is capable when carbon dioxide and methane gas are yielded out. The conversion is shown below:-

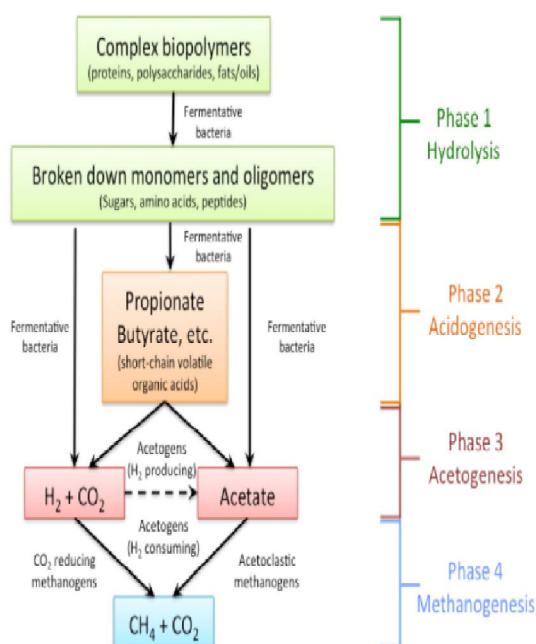


Fig 3. Stages of production of biogas[1-2]

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XI. PROPERTIES OF BIOGAS

Biogas consists of methane to a major extent along with carbon dioxide and other gases and their proportions depend on the production environment and techniques adopted. Few traces of hydrogen sulphide, ammonia and nitrogen gas may also be present. Biogas is normally drenched with water vapour. The energy value of pure methane is 9.81 KWh/Nm³ [8]. Taking into consideration, the relative amounts of methane, carbon dioxide and other gases, the energy value of biogas varies between 4.5 to 8.5 KWh/Nm³. The presence of sulphur compounds is responsible for the stench of biogas. Biogas may ignite at concentrations of about 5-20% in air. The table below shows the comparison of properties for LPG gas, biogas and natural gas[11].

Table 2. Comparison of properties of three gases

Property	Unit	LPG	Biogas	Natural Gas
Calorific Value, lower	MJ/Kg	46.1	20.2	48
Density	Kg/m ³	0.525	1.2	0.83
Odour	-	Faint smell	Low odour	Garlic-like
Ignition Temperature	Fahrenheit	770-1076	1200 to 1380	1163
Hydrogen Sulphide	Ppm	Absent	<500	3

XII. USES OF BIOGAS

INDUSTRIAL USES

Biogas is combustible it can effectively replace natural gas as an alternative and used for running various machineries in industries. With minor alteration engines can be made compatible to run with mixture of biogas and dual fuel.

AGRICULTURAL USES

Biogas can be utilized to run farming equipments like threshers, grinders, tractors, pumps or generate electricity. The slurry which is left over after the production can be used as organic fertilizer, which is nutrient rich. It is better than the chemical fertilizers because it does not cause eutrophication[12].

HOUSEHOLD USE

The organic waste that is generated every day in household can be utilized to make biogas which can be used as cooking gas. This will help in conservation of natural resources additionally it also aids in waste management as the initial material required for production are leftover biodegradable substances [7].

ALTERNATIVE VEHICLE FUEL

Biogas can be used as an alternative vehicle fuel. It can be incorporated with various dual fuels. It can be used to run both spark plug and diesel engines. The spark engine requires minor modifications to run in biogas. Ignition systems do not need any modification other than timing adjustments [9].

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BOOSTING THE ECONOMY

Large scale implementation of the biogas plant will not only benefit the environment but it will also help in boosting the economy of the nation by generating thousands of jobs in the process. The government of India has launched a program called National Biogas and Manure Management Program (NBMMP) to increase the total biogas output of the nation with a budget of 650 crore which targets to setup over 6.5 lakh biogas plants throughout the nation. It is estimated that after setting up these plants the total production annually would be 4745 lakh cubic meter biogas.

XIII.PREVENTION OF AIR POLLUTION THROUGH BIOGAS

The impact of fossil fuels on the nature is worsening every year. The rates of pollutants and other harmful substances in air is spiking. Global weather around the world is changing with increasing instances of record breaking temperatures worldwide. Not only this but with growing use of natural resources we risk depletion of fossil fuels in the near future. In order to tackle this problem large scale shift in methods of energy production is required. Biogas is cheap and an efficient alternative to natural gas which can also be employed for various other purposes. It can be produced using the biodegradable waste in an eco-friendly way [4]. One of the main advantages of biogas is that it can be used to run vehicle engines with minimum modifications. If incorporated in large scale this will greatly reduce the amount of pollutants which are emitted in the atmosphere and control the air pollution. In addition the exhaust gases released by the engines while using biogas as a fuel contain lesser amount of greenhouse gases than the traditional fuels, thereby helping in slowing down global warming. Biogas can be produced in cheap and reliable ways domestically. Biogas plants can be setup in large scale extensively utilizing the organic waste generated in a particular area thus also improving the scenic beauty of the place [9-10]. Additionally, these biogas plants can also double up as fertilizer producing factories as the slurry which is generated after the production of the biogas is nutrient rich and eco-friendly. In general, biogas provides solution to a many of the problems, given enough funding and government support this method can improve the economy, environment and energy crisis of the country within a decade[10-12].

XIV.CONCLUSION

Research in production and application of biogas has been conducted by many universities around the globe. Than why aren't we implementing this technology? The answer is "Lack of awareness". A huge potential market for production of biogas is available. With proper investment and planning this untapped potential can be harnessed. Everyday more and more number of people are exposed to the benefits of the biogas, thus inspiring investments and innovation in this emerging technology.

The AFPRO (Action for Food Production) are an NGO who are leading in the biogas awareness program in the country. With an active partnership with the CHF (Canadian Hunger Foundation) they've demonstrated the benefits of the biogas to millions of people and constructed thousands of biogas plants. With increasing number of such organizations the benefits of this technology is becoming more popular and people are recognizing that it can be used as an efficient and clean source of energy. The only limitation for this technology is the governmental and financial one which can be overcome by increasing the incentives attracting investors in this area. India produced 20,757 lakh cubic meters of biogas in 2014-15 which is 5% of the total LPG consumption. Government provided subsidies are helping farmers to setup domestic biogas plants. The future of this technology is promising and hopefully it will help us to solve few of many environmental problems that we face today such as air pollution, energy crisis and waste management.

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