FEDERAL UNIVERSITY OF TECHNOLOGY
MINNA

ALTERNATIVE ENERGY SOURCES: THE ROLE OF MICROORGANISMS

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INAUGURAL LECTURE SERIES 20

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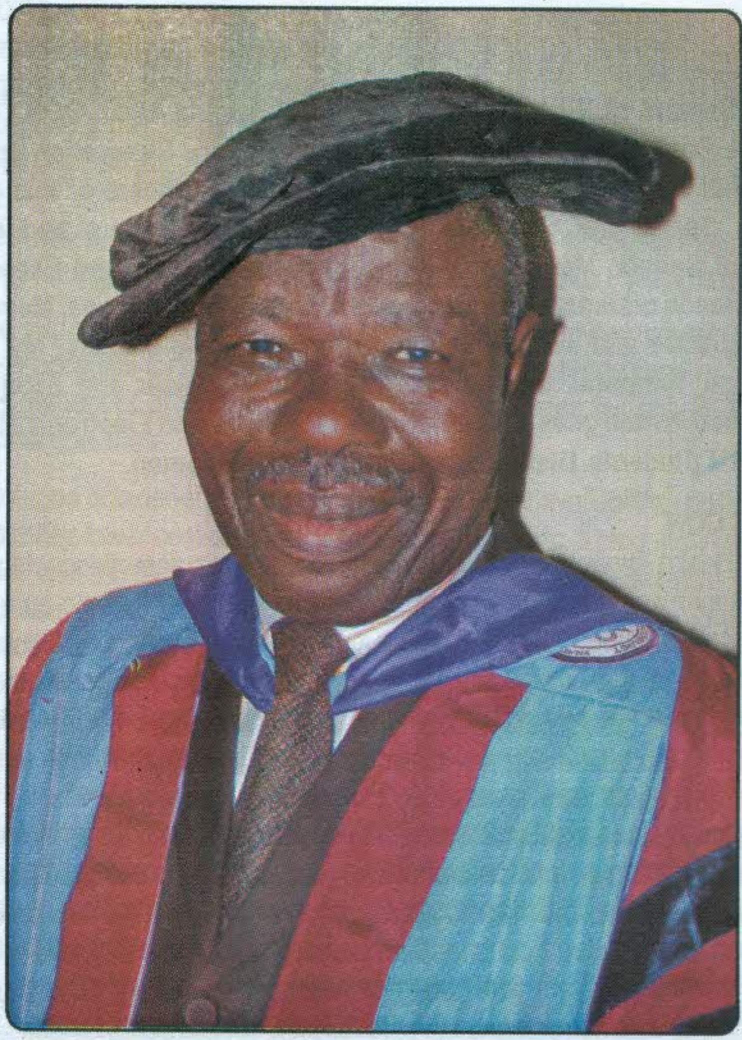

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ALTERNATIVE ENERGY SOURCES: THE ROLE OF MICROORGANISMS

COURTESIES:

The Chief Servant of Niger State, Dr. Muazu Babagida Aliyu, OON (Talba Minna), The Executive Governor of Niger State. Mr. Vice Chancellor, Deputy Vice Chancellors, Registrar, Bursar, Other Principal officers of this great University, Deans and Directors, Distinguished Professors and other members of Senate, Members of Niger State Legislature and Executive Councils, Heads of Departments and other academic colleagues, Members of Administrative and Technical Staff, Your Royal Highnesses, My Lord Spiritual and Temporal, Members of my family, Nuclear and Extended, Distinguished invited guests, Gentlemen of the press and Electronic Media. Greatest FUT Students, Distinguished ladies and gentlemen.

INTRODUCTION

The World Health Organization (WHO) defines waste as something which the owner no longer wants at a given time and space and which has no current or perceived market value. Wastes may be gaseous, liquid or solid. Liquid and gaseous wastes are free flowing and can easily migrate from one place to another; solid wastes are not free flowing (Environmental Protection Agency, (EPA), 1972). However, what one regards as waste may not be totally useless as long as it can be recycled to produce new product(s). For example, guinea corn husk, millet husk and spoilt fruits (agricultural waste with no appreciable value to industries) are used as alternative and cost-effective feed stock for the production of bioenergy (Oyeleke and Jibrin, 2009, Oyeleke *et al.,* 2010). Also microbial enzymes can be produced from cheap and readily available agricultural wastes such as cassava peels, yam peels and rice husks which currently constitutes a menace to solid waste management (Oyeleke and Oduwole 2009, Oyeleke *et al.*, 2010a and b, Ibrahim *et al.*, 2011, Oyeleke *et,al.*, 2011). Energy conservation and energy production from cheaper sources are the immediate need of our time. Biotechnology can make a lot of contribution in this context, by increasing the acceptability of biomass, biogas, fuel and alcohol as feasible alternatives.

Bioenergy is energy generated through biological feed stocks and are renewable in origin. Example includes fuelwood, charcoal, livestock manure, biogas, biohydrogen, bioalcohol, microbial biomass, agricultural waste and by-products, energy crops, and others (Yeole *et al.*, 1996, Oyeleke and Jibrin 2009, Oyeleke *et al.*, 2009).

The main sources of bioenergy are:

(1) Agricultural residues and wastes

(2) Purpose-grown crops, e.g. palm fruit and seeds.

(3) Wild vegetation.

In their raw forms, these sources are usually called biomass, though the term "energy feedstock" is also used, mostly for purpose-grown energy crops.

Unlike oil, biomass can be produced in just about every country. Bioenergy already accounts for nearly 10 percent of total world energy supplies. It accounts for 33 percent of energy used in developing countries but only 3–4 percent in industrial countries.

Advantages of bioenergy generation include: bullet availability, eco-friendliness, affordability, lower cost of production, less pollution etc. If bioenergy generation is coupled with the tapping of unutilized biomass, wasteland utilization for biomass production or treatment of solid/liquid wastes, then pollution abatement and resources utilization will be simultaneously achieved. Development of reactor designs and gene manipulations of microorganisms have made the task easier and bioenergy from wastes has become a reality (Jogdand, 1994, Schor, 1994, Oyeleke and Jibrin 2009, Oyeleke *et al.,* 2010). In recent years, bioenergy has drawn policies, which now total about $320 billion a year. Moreover, oil and coal are unevenly distributed among countries; all countries could generate some bioenergy from domestically grown biomass of one type or another, thereby helping to reduce their dependence on imported fossil fuels that is exhaustible (Hazell and Pachaur, 2006).

Effluents from dairy, cider, pectin, confectionary, yeast, and brewing, distilling, and chemical plants can be treated to produce energy. In Italy, this process has been used to treat effluents from cheese and ham processing plant, and in Spain, it is used in slaughterhouse operations. Bioenergy plant can make a financial profit, as well as satisfy statutory requirements for disposal of waste (Veermani, 1994).

Biotreatment of wastes can fall into two basic types: Aerobic and Anaerobic. Over the years, aerobic biotreatment has been considered to be more efficient in reduction of Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) reduction, which proved better for nitrogen and phosphorus removal, and quite applicable for wide range of wastes and more stable process. Anaerobic biotreatment has been considered to be sensitive to toxicity and less reliable in performance in terms of COD reduction. However, in recent years, this misconception was proved untrue. On the contrary anaerobic processes are preferred as they produce less sludge, consume less energy, can operate at high organic loading rate and produce no odour or aerosol nuisance. Thus, anaerobic biotreatment of wastes is now gaining prominence due to energy production that is possible along with pollution abatement (Vermani, 1994).

Total global energy consumption is huge—about 400 EJ (exajoules) per year—and is expected to grow to 50 percent by 2025. Most of the increase will occur in developing countries. Majority of this demand is currently met by fossil fuels, particularly oil. Rapid growth in oil demand, finite oil supplies, and political instability in many of the major oil-exporting countries are pushing up oil prices and making them more volatile. This trend seems destined to continue. Consequently, many importing countries are looking to expand and diversify their energy sources and are looking at bioenergy as a potential alternative prospect within their broader energy portfolios. Already, bioenergy accounts for 10 percent of world energy supplies, and the potential to better exploit many unused crop residues and to grow dedicated energy crops is enormous. Bioenergy's potential will also increase as second-generation technologies come on line, enabling more efficient conversion of cellulose-rich biomass to transport fuels and electricity. Technological advances will not only help make bioenergy more competitive with fossil fuels on price, but will also expand the range of feed stock that can be used, some of which (like fast-growing grasses and trees) can thrive in less fertile and more drought-prone regions that are less competitive with food and feed than current feedstock like sugarcane, maize, and cassava. Many developing countries with tropical climates may have a comparative advantage in growing energy-rich biomass and could become major exporters. Africa in this instance has the biophysical potential to become an important producer and exporter of bioenergy.

In developing countries, biomass also constitutes the main source of household energy in rural and urban areas. Urban households primarily use wood and charcoal for cooking and heating but with continuing rapid growth in urban populations, finding sustainable ways of meeting this large and growing demand is also a challenge. The interest in bioenergy is growing concern more so that global climate change and the need to reduce greenhouse gas emissions are daily securing more prominent.

Presently there is a big difference in demand between developing regions of the world in biomass energy supply. For example, biomass accounts for more than 60 percent of final energy use in Africa, 34 percent in Asia, and 25 percent in Latin America. Most biomass in industrialized countries is converted into electricity and heat in industrial-scale plants, whereas in developing countries, it is mostly burnt by rural households as a source of energy for cooking and heating. Biomass is in fact the main source of household energy use for between 2 to 3 billion people in the developing world (Ramasamy, 1998).

BIOTECHNOLOGICAL DEVELOPMENTS

Immobilized cell anaerobic reactors are now used in more numbers for treating industrial wastes. This is due to their better performance and their capacity to retain biomass. The following systems are available in immobilized technology with anaerobic conditions:

(a) Upflow anaerobic sludge blanket reactor (UASB)

(b) Hybrid reactors

(c) Upflow fixed film anaerobic filter

(d) Downflow fixed film anaerobic filter

(e) Expanded bed reactor

(f) Fluidized bed reactor

The amount of active biomass decides the loading capacity and subsequent bioenergy production and also waste-water depollution. Immobilised cell anaerobic reactors are only able to treat waste-waters with low concentration of particulate matter. The development of stable associations of microorganisms is required for bioenergy production. Concentration of biomass in the reactor and minimum hydraulic retention time are achieved which result in a smaller reactor volume and reduced investments.

Ethanol production from corn starch or mollasses is now considered to be an attractive proposition. If alcohol can be produced from abundantly available raw material like lignocellulosic materials, from wastes of food industry, dairy, paper industry, agricultural wastes, and other industrial wastes then it is still beneficial. Biotechnological development is on to modify or engineer organisms to use industrial wastes and other cheap substrates (lignocellulosic biomass) more effectively. Also work is on to modify fermentation conditions to make waste to ethanol a feasible process (Oyeleke and Jibrin, 2009, Oyeleke *et al.*, 2009).

Saccharomyces cerevisiae, *Zymomonas mobilis*, *Candida utilis*, *Candida pseudotropicalis*, *Pseudomonas aeruginosa*, *Streptococcus* sp., *Bacillus* sp., *Fusarium* sp., *Mucor* sp., *Gloeophyllum sepiarium*, *Pleurotus ostreatus etc* are the organisms which are being used to produce ethanol from various raw materials. Others having potentials to produce ethanol and certain advantageous positions are, *Clostridium thermoacellum*, *Thermoanerobacter ethanolicus*, *Kluyeveromyces fragilis*. Recently, however, efforts are being made to use engineered organisms having the desired capacity to use the target wastes. These organisms have capacity to either directly use starch or cellulose-like polysaccharides without need of prior solubilization or can use wide range of sugars like hexoses and pentoses. Also efforts are on to increase sugar tolerance and ethanol tolerance of producing organisms. Simultaneous saccharification and fermentation (SSF) and direct microbial conversion (DMC) are more preferred than separate hydrolysis and fermentation (SHF).

BIOENERGY FROM FOOD INDUSTRY WASTES

Using waste biomass to produce energy can reduce the use of fossil fuels, reduce greenhouse gas emissions and reduce pollution and waste management problems. A recent publication by the European Union highlighted the potential for waste-derived bioenergy to contribute to the reduction of global warming. The report concluded that 19 million tons of oil equivalents are available from biomass by the year 2020, 46% from bio-wastes: municipal solid waste (MSW), agricultural residues, farm waste and other biodegradable waste streams. European Environment Agency, (EEA) 2006, Marshall, 2007).

Effluents from food processing industries are most suitable for biogas production. These effluents have high BOD due to easily biodegradable organic matter. Effluents rich in carbohydrates are rich in methane production but those with high fat and protein contents are also suitable. This is the reason why wastes from food processing units find more potential in biogas production. Breweries and other processing plants including dairy industries, sugar plants, grain mills, gasohol plants. and the like, produce wastewater that is characterized by its content of complex organic matter, either in solution or as volatile, suspended solids, which can be treated anaerobically to effectively reduce the pollutants and to generate bioenergy in the form of methane gas. Food processors including dairies, canneries, sugar plants, distilleries, breweries and the like, may have totally different effluents, each high in carbohydrates, but each demanding a particular engineering approach for maximum efficiency and greatest savings. Within the same industry there may also be differences in processes used. Therefore, data gathered from an on-site pilot plant study is essential when engineering the full size plant in terms of cost-effective design. The price of the pilot plant operation will be recouped many times in design, construction, and operation savings.

Wastes generated from vegetable processing industries account for about 43% of the total wastes (Oyeleke *et al.*, 2009). By-product wastes from vegetable processing originate in canneries in two main forms: discrete solids (leaves, trimmings, stems, peels, pods, husks, cobs, silk, and defective processed vegetables) and screened effluent (washing, husking, desilking, blanching, cutting, peeling, slicing, clipping, screening, grading, and inspection). Some solids waste from canneries processing vegetable crops are given away to farmers for use as animal feed. The remainder must be either applied to land or placed in a landfill. The voluminous effluent streams from canneries represent high BOD sugar solutions which cannot be released to surface waters and must therefore be sprayed by irrigation on farmland or processed at high expense through private or municipal treatment plants. Costs of disposal vary depending on the type of waste and the method of treatment employed.

Ethanol can be produced from vegetable processing wastes. Solids from vegetable wastes are pressed hydraulically, resulting in a liquid rich in soluble sugars. The pressed residue contains the bulk of the crude fiber carbohydrate (cellulose and hemicellulose). The soluble or extractable carbohydrates are present in the liquid portion of the screened effluent. It is estimated that the ethanol yield from the byproduct carbohydrates will produce 172 gallons per ton from the starch fraction and 120 gallons per ton from the cellulose/hemicellulose fraction. The extractable carbohydrates are directly fermentable without enzymatic saccharification. The extractable carbohydrate concentrations in the liquid portion of these wastes are very low, though ideally, sugar concentrations of the liquid feedstock for fermentation should be in the range of 15 to 20 percent.

Most anaerobic digestion technologies are commercially available. Where unprocessed wastes cause odour and water pollution such as in large dairies, anaerobic digestion reduces the odour and liquid waste disposal problems and produces a biogas fuel that can be used for process heating and/or electricity generation. At Langerwerf Dairy in Durham, California, cow manure are scraped and fed into a plug flow digester. The biogas produced is used to fire an 85 kW gas engine. The engine operates at 35 kW capacity level and drives a generator to produce electricity. Electricity and heat generated are able to offset all dairy energy demand. The system has been in operation since 1982. The installation of an anaerobic wastewater treatment system is an extremely attractive economic and environmental alternative considering that this is an era of critical energy shortages, substantially higher energy prices. Utilization of the anaerobic process to treat these effluents can produce to the user the following benefits:

- An 85% to 95% reduction in effluent loading, most of which are based on effluent BOD, volatiles, and suspended solids content.
- Production of energy in the form of 900 BTU or more methane which is useful as fuel in any natural gas application and which can provide a return on investment that an aerobic plant cannot.
- Facilities for plant financing.
- The project can be depreciated as a certified pollution control facility for Federal tax purposes over a five year span.
- In the US, the Owner can be eligible for 50% capital cost.
- The anaerobic fixed-film systems have been successfully installed for waste management of several agro-industrial plants in Thailand.
- Other potential beneficiaries within the agro-industry from this technology are:
  Fruit and vegetable processing factories, Tapioca starch factories, Fructose, glucose, and dextrose production plants, Soybean curd production facilities Pulp and paper industry.

The systems take up much smaller space than the conventional ones because of a combination of high reduction rate (60 - 80%) of biomass and low hydraulic retention time (0.5 - 3 days). The physical size of a typical unit is 10 - 20 times smaller than conventional ones. This factor is an important consideration for factories which are located in areas where land cost is high or prohibitive. The systems are virtually odorless. The biogas produced provides a cheap source of energy for the factory.

BIOENERGY FROM TEXTILE WASTES

Jute caddies, the unspinnable short fibres are generated by the jute mill looms. Jute caddies are a ligno-cellulosic waste. India produces 0.28 million quintals of this material and is used as boiler fuel or is wasted and contribute to pollution. The Calcutta-based Jute Technological Research Laboratory (JTRL) has produced biogas using 2.5% of this material, in 20 days (Jogdand, 1994). If alkali-treated caddies are used instead of raw caddies, the same is possible in 15 days. The remaining slurry after biogas production is rich in Nitrogen, Phosphorus and Potassium (N, P, K) nutrients and is comparable to the farm yard manure. Alkaline treatment of caddies helps solubilization of ligno-cellulosic material; hence the time of fermentation is reduced.

Similarly, the textile industry in India generates willow-dust which is one of the solid cellulosic waste materials produced during the processing operations. 30,000 - 33,000 tonnes of willow-dust is generated per year by the textile industries in India. Composting, direct burning and anaerobic digestion for biogas production are the three alternatives available for the disposal of willow-dust. Biogas production from willow-dust was first demonstrated by Cotton Textile Research Laboratory (CTRL), Mumbai. Willow-dust contains celluloses, hemicelluloses and C: N ratio is 25:1. Plant producing $17m^3$ biogas from 100kg willow-dust in thirty days is operating satisfactorily. A large scale trial was taken by the Apollo Mills, Mumbai. With the help of 6 digesters, 12 tones of willow-dust were digested per month. $350m^3$ of biogas was obtained in each digester handling 2 tones of willow-dust with 90 days retention period. Slurry obtained after digestion serves as good manure. With a modified process requiring less water to substrate ratio 1.5:1), $250m^3$ biogas can be obtained from 1 tone of willow-dust in 60 days (Jogdand, 1994).

BIOENERGY PRODUCTION FROM PAPER & PULP INDUSTRIAL WASTES

Biogas from glue industrial wastes was discovered in India. While dung has 18% solids, glue industry wastes have 61% solids and anaerobic fermentation is best when the matter contains 7-9% solids. Thus, glue industry wastes should prove useful for biogas production and digested slurry will serve as organic manure. Major byproducts of processing cellulosic biomass include lignin, furfural, carbon dioxide and inorganic material. Lignin has a fuel value. Inorganic material like clay, titanium dioxide, calcium carbonate may be required to be removed as it may be harmful to saccharification process in ethanol production. However, pulp and paper mill waste is rich in cellulose and has a potential for ethanol production. It was determined that pulp and paper mill sludge has an ethanol yield potential of 51 to 74 gallons of ethanol per dry ton. Cellulose must be hydrolyzed to glucose before fermentation to ethanol. Conversion efficiencies of cellulose to glucose may be dependent on the extent of chemical and mechanical pretreatments to structurally and chemically alter the pulp and paper mill wastes. The method of pulping, the type of wood, and the use of recycled pulp and paper products also could influence the accessibility of cellulose to cellulase enzymes.

The chemical contaminants in the sludge from pulp and paper processing, have the potential to interfere with the hydrolysis of the cellulose material to glucose, or inhibit fermentation activity however printing inks do not have any adverse effects on enzyme hydrolysis or yeast fermentation. This may reduce ethanol yield, but these effects have not yet been quantified. Ethanol plants of the future will be able to process all types of paper and pulp waste blends without the need for separation of waste streams.

Paper has a fine result when it is recycled; approximately 10 to 15% of the recycled paper must be purged because the fibers are too short for reuse. Pulp and paper wastes may also be treated to produce methane. Pulp and paper industry waste-waters have 11500 mg/l, COD. At a hydraulic retention time of 5 days and COD loading rate of 2 kg m^{-3} day^{-1}, a digester produced a COD reduction of 60% and methane yield of 1.1 m^3/kg COD added. The gas contained 81% methane. Indian industries have been slow in adopting the energy efficient biological process for treatment of effluents in-spite of the fact that proven technology and alternate designs of suitable bioreactor systems are available. Integrated anaerobic-aerobic treatment of pulp mill effluent has been used by Pudmjee Pulp and Paper Mills Ltd. At Pune, energy is recovered as biogas. This biofuel contributes to one-sixth of the steam demand of the paper mill.

ANAEROBIC DIGESTION (AD)

Anaerobic Digestion (AD), is a biological process, where the methane released by the synergistic actions between bacteria and archaea are contained and used to create energy. Anaerobic Digestion uses biowaste such as manure and municipal solid waste (MSW) as a feedstock. The manure or waste is bagged and broken down using bacteria and water (Fig. 1). This process releases the methane in the bag, and it is siphoned off into another holding bag. From there, the gas is used to power turbines which generate electricity.

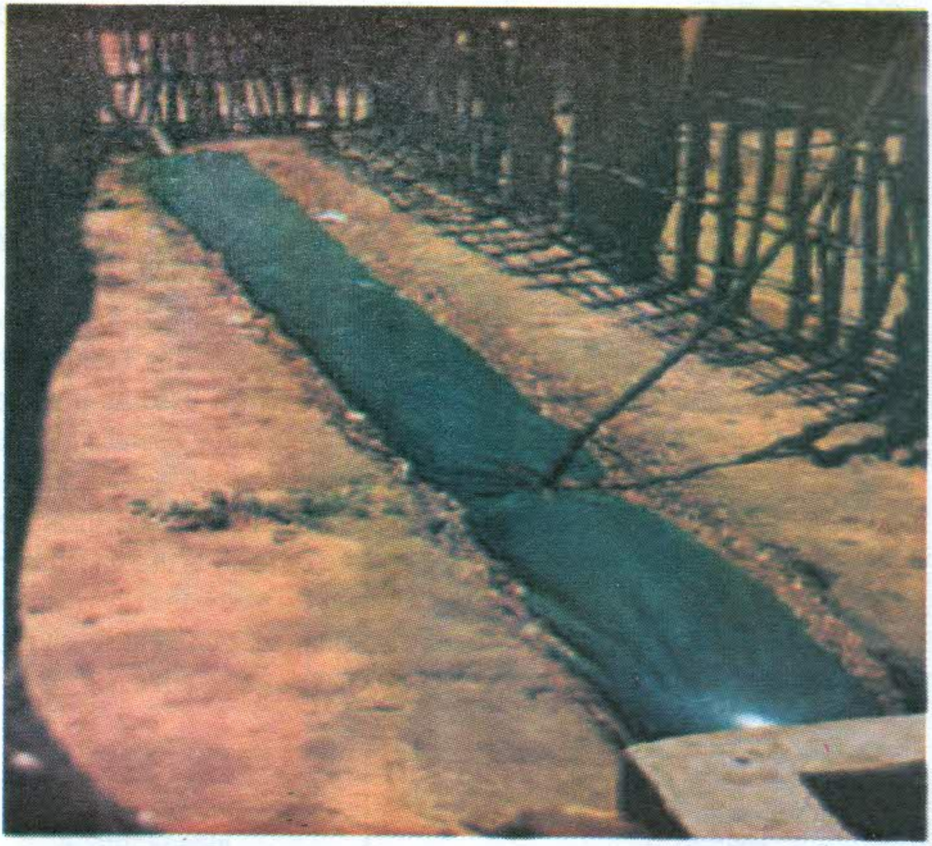

Fig 1: Bagging process in anaerobic digestion process

Source: http://www.uwec.edu/grossmzc/martycw.html, 2008.

The first stage in anaerobic digestion is hydrolysis (Figure 2). Hydrolysis is the microbial conversion of a wide range of solid organic materials into sugars, organic acids and amino acids. Several facultative bacteria are involved in this process; these include *Bacillus*, *Proteus*, *Clostridium*, *Pseudomonas*, *Vibrio* and *Staphylococcus* species. These microorganisms ferment the complex organic materials into alcohol, hydrogen, carbon (iv) oxide and higher fatty acids which are subsequently converted to hydrogen, carbon dioxide, and acetate through Acidogenesis by homoacetogenic bacteria such as *Clostridium*. Finally, in the process of methanogenesis, Methanogenic bacteria such as *Methanococcus*, *Methanobacterium* and *Methanosarcina* produce biogas, a mixture of 55-70 % methane, 25%-35% carbon dioxide, and trace elements of nitrogen and hydrogen sulfide. Conducted in an airless environment, the methane can be captured and used to power a gas turbine or even fuel cells (Oyewole, 2010).

Microbial growth and natural biogas production is very slow at ambient temperatures. It tends to occur naturally wherever high concentrations of wet organic matter accumulate in the absence of dissolved oxygen, most commonly in the bottom sediments of lakes and ponds, in swamps, peat bogs, intestines of animals, and in the anaerobic interiors of landfill sites. The ultimate yield of biogas depends on the composition and biodegradability of the waste feedstock but its rate of production will depend on the population of microorganisms, their growth conditions and the temperature of the fermentation. When used as a waste treatment process, the digestion rate is greatly increased by operating in the mesophilic temperature range (35-40°C). For certain feedstocks, it can be further increased by operating at thermophilic (50-60 °C) temperatures. Anaerobic digesters are available at competitive rates and are currently in use on farms in some countries, although on a small scale. Utilizing the methane in this manner also aids in odor control and prevents the methane from seeping dangerously into the atmosphere, thereby raising the levels of greenhouse gases and smog.

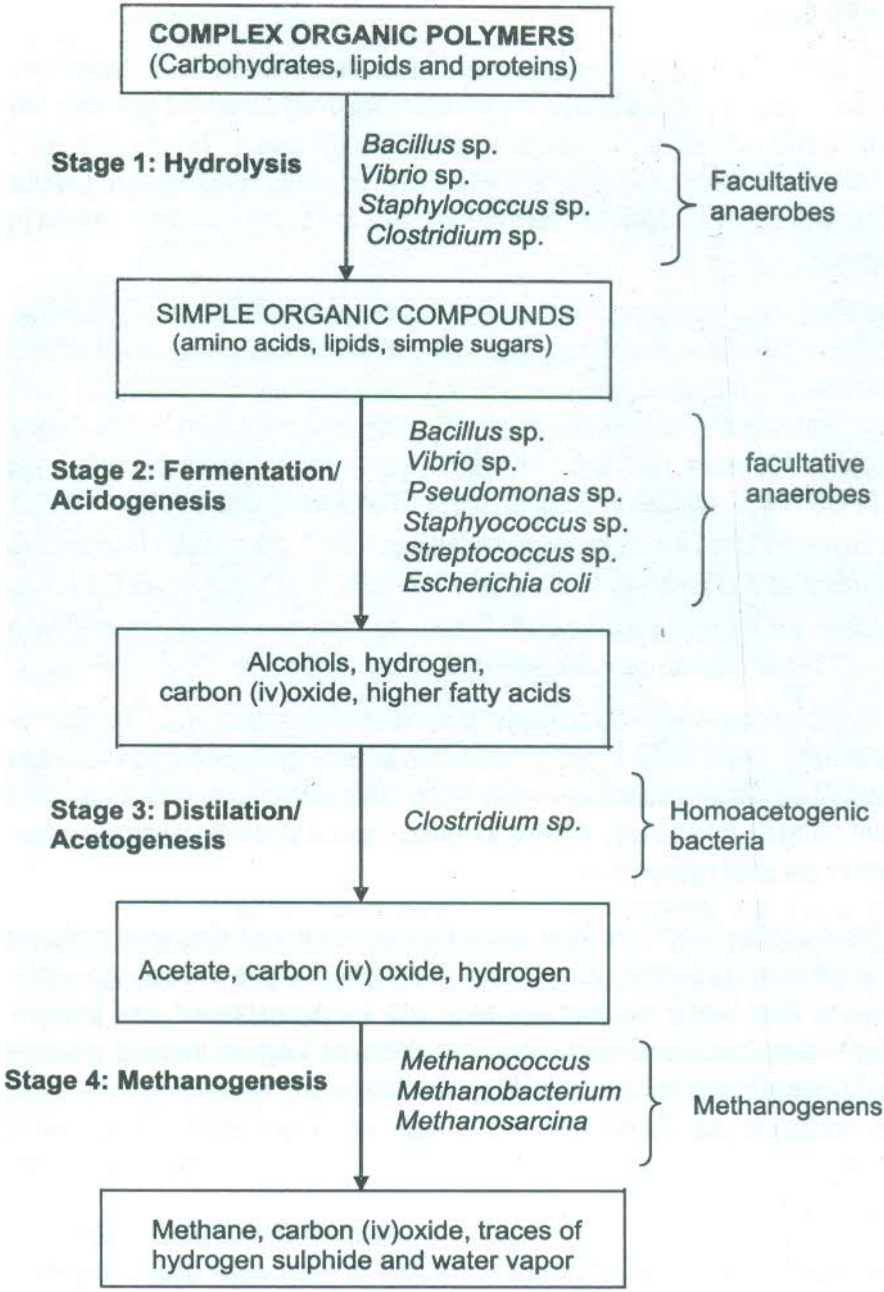

Fig 2: Flow chart showing stages of methanogenesis.

Source: Oyewole, 2010

Landfill Gas

Landfill sites (Fig 2.) generate gases as the waste buried in them undergoes anaerobic digestion. These gases are known collectively as landfill gas: this can be burned and is a source of renewable energy. Landfill gas (LFG) can be burned either directly for heat or to generate electricity for public consumption. Landfill gas contains approximately 50 percent methane, the same gas that is found in natural gas.

If landfill gas is not harvested, it escapes into the atmosphere: this is not desirable because methane is a greenhouse gas, with more global warming potential than carbon dioxide (Intergovernmental Panel on Climate Change, IPCC 2007, Third Assessment Report, 2007, Environmental Protection Agency, EPA, 2007). Over a time span of 100 years, methane has a global warming potential of 23% relative to CO_2. (IPCC Third Assessment Report, 2007). Therefore, during this time, one ton of methane produces the same greenhouse gas (GHG) effect as 23 tons of CO_2. Combustion of methane yields) CO2 and H_2O ($CH_4 + 2O_2\ CO_2 + 2H_2O$). So by harvesting and burning landfill gas, its global warming potential is reduced by a factor of 23, in addition to providing energy for heat and power.

Landfill gas uses a similar technology to anaerobic digestion and it carries the same benefits. It occurs as a by-product of the decomposition of solid waste and consists of 50 percent methane (natural gas), 45 percent carbon dioxide and 4 percent nitrogen. Additionally, it helps to reduce landfill waste by using the waste stream for electricity generation.

The Trans-Jordan Landfill in West Jordan is even experimenting with capturing natural gas from the decomposing landfill. "Collecting the gas and selling it will be a lot better than letting the methane seep into the atmosphere," said Dwayne Wooley, Trans-Jordan's General Manager. "And as long as there is garbage decaying, we will have natural gas (Oberbeck, 2005).

Fig 3: Landfill

There are two ways to collect landfill gas, the traditional method is called conventional drilling and the other is called push-in collection. Before gas can be collected a 3-D map of the landfill is often drawn up to categorize where the gas is, and how it can best be obtained. The traditional drilling method works as if drilling for gas anywhere else, but with adjustments made for the landfill terrain. Often the pipes are laid through the landfill vertically to make collection easier. Then a blower and a flare, pump the gas out of the landfill into collection areas (Brookshire, 2005).

FIRST GENERATION BIOFUELS

"First-generation fuels refer to biofuels made from sugar, starch, corn, wheat sweet sorgum, vegetable oil, or animal fats using conventional technology'(UN biofuels report 2007). The most common first generation biofuels are discussed below".

(i) Vegetable oil

Vegetable oil can be used for either food or fuel; the quality of the oil may be lower for fuel use. Vegetable oil can be used in many older diesel engines (equipped with indirect injection systems), but only in warm climates. In most cases, vegetable oil is used to manufacture biodiesel, which is compatible with most diesel engines when blended with conventional diesel fuel. No engine manufacturer explicitly states that straight vegetable oil can be used in their engines however, Used vegetable oil (e.g. from deep fat fryers) can be filtered and processed into biodiesel.

(ii) Biodiesel

Biodiesel is the most common biofuel in Europe. It is produced from oils or fats using trans-esterification and is a liquid similar in composition to mineral diesel. Its chemical name is fatty acid methyl or Fatty acid methyl ester (FAME). Oils are mixed with sodium hydroxide and methanol (or ethanol) to produce biodiesel (FAME) and glycerol. 1 part glycerol is produced for every 10 parts biodiesel.

Biodiesel can be used in any diesel engine when mixed with mineral diesel. In some countries manufacturers cover their diesel engines under warranty for 100% biodiesel use, although Volkswagen Germany, for example, ask drivers to make a telephone check with the VW environmental services department before switching to 100% biodiesel . Many people have run their vehicles on biodiesel without problems. However, the majority of vehicle manufacturers limit their recommendations to 15% biodiesel blended with mineral diesel. In many European countries, a 5% biodiesel blend is widely used and is available at thousands of gas stations (Concawe European WTW study, 2008). In the USA, more than 80% of commercial trucks and city buses run on diesel. Therefore "the nascent U.S. market for biodiesel is growing at a staggering rate—from 25 million gallons per year in 2004 to 78 million gallons by the beginning of 2009. By the end of 2010 biodiesel production was estimated to increase fourfold to more than 1 billion gallons," as reported by energy expert Will Thurmond.

(iii) Bioalcohols

Biologically produced alcohols, most commonly ethanol and less commonly propanol and butanol, are produced by the action of microorganisms and enzymes through fermentation.

(iv) Bioethanol

Bioethanol is the most common biofuel worldwide. It is an alcohol fuel produced by fermentation of sugars derived from wheat, corn, sugar beet and sugar cane. The production methods used are enzymatic digestion (to release sugars from stored starches e.g. from wheat and corn), fermentation of the sugars, distillation and drying.

In the sugar fermentation process, yeast or any other suitable microorganism is added to the solution obtained for the hydrolysis. The yeast or fermenting microorganism contains an enzyme called invertase which acts as a catalyst and helps to convert sucrose sugars to glucose and fructose ($C_6H_{12}O_6$). The chemical reaction is shown below:

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$$\underset{\text{Sucrose}}{C_{12}H_{22}O_{11} + H_2O} \xrightarrow[\text{Catalyst}]{} \underset{\text{Fructose + Glucose}}{C_6H_{12}O_6 + C_6H_{12}O_6}$$

The glucose and fructose are bioconverted by another enzyme called zymase, which is also contained in the yeast to produce ethanol and Carbon dioxide.

$$\underset{\text{Fructose/Glucose}}{C_6H_{12}O_6} \xrightarrow[\text{Catalysts}]{} \underset{\text{Ethanol}}{2C_2H_5OH_1 + 2CO_2}$$

(Jeffries and Jin, 2004).

Bioethanol is a high-octane, water-free alcohol. In its purest form, bioethanol is a colorless clear liquid with mild characteristic odor that boils at 78°C and freezes at –112°C. It can be used as liquid fuel in internal combustion engines either on its own or blended with petroleum. Hydrous bioethanol (95% purity) is used as pure alcohol fuel. Anhydrous bioethanol (99.5% purity) is used for blending with gasoline. Bioethanol can be used in petrol engines as a replacement for gasoline; and can be mixed with gasoline to any percentage. All petrol engines can run on blends of up to 15% bioethanol with petroleum/gasoline. For higher percentage blends, engine modifications are needed. Many car manufacturers are now producing flex-fuel vehicles, which can run on any combination of bioethanol and petrol, up to 100% bioethanol.

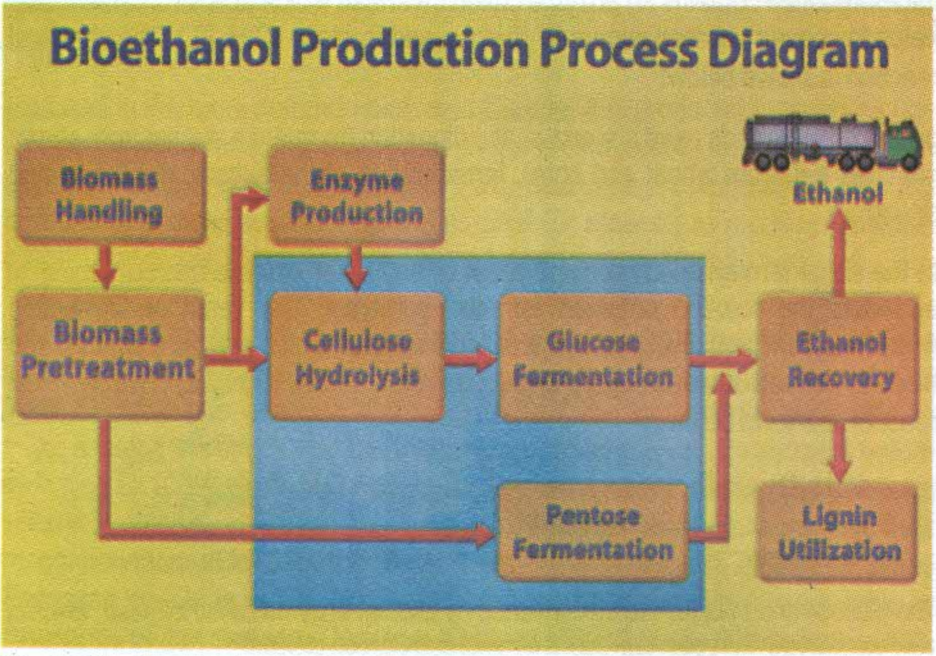

Fig 4: Bioethanol Production Process

Source: Hazell and Pachaur (2006)

History of bioethanol use

Bioethanol was one of the first fuels used in automobile engine. It was used extensively in Germany during World War II and also in Brazil, the Philippines, and the United States. During the postwar period, as petroleum supplies became cheap and abundant, gasoline largely replaced bioethanol as an automobiofuel. In 1970s, when the supply of oil was restricted, bioethanol re-emerged as an alternative to or extender for petroleum-based liquid fuels (ethanol as an extender was added to these fuels to increase their volume).

What makes bioethanol a suitable alternative to gasoline?

The properties of bioethanol make it suitable for use as a substitute for gasoline:

Energy per unit volume: 22MJ/liter

Octane Index (research) : 106

Specific Gravity at 15.5^{0}C: 0.79 Kg/liter.

How many countries have been producing and using Bioethanol as alternative transportation fuel?

Today, 12 countries produce and use a significant amount of bioethanol. In Brazil, for example, one third of that country's automobiles use pure bioethanol as fuel; the remaining two thirds use mixtures of gasoline and ethanol. France, the United States, Indonesia, the Philippines, Guatemala, Costa Rica, Argentina, the Republic of South Africa, Kenya, Thailand and Sudan are other countries with government or private ethanol fuel programs (Fig 5).

Fig 5: Biethanol fueled car

What are the benefits of using bioethanol?

Major vehicle manufacturers worldwide particularly vehicles manufactured and those sold in US and Europe that meets these two countries vehicle emission standards and which are also now sold in the Philippines approve the use of E-10 blended unleaded which provides the following benefits:

- Improves the combustion efficiency of gasoline because of the oxygenates that is inherent to bioethanol thus translating to better performance, reduced carbon monoxide and unburned hydrocarbon emissions which in most cases improves fuel economy.
- Provides high octane rating at low cost as an alternative to harmful fuel additives
- Biodegradable without harmful effects on the environment.
- Reduces greenhouse gas emissions because it burns more efficiently thus significantly reducing unburned carbons.
- High volumetric efficiency and burns cooler than straight gasoline helping to keep valves cool which contributes to increase in power.
- Bioethanol expands the market to farmers e.g. Filipino farmers, particularly the sugar sector, thus enhancing rural economic development.
- Pure bioethanol can replace gasoline in modified spark-ignition engines, or it can be blended with gasoline at up to thirteen percent concentration (13%) to fuel unmodified gasoline engines.
- Blending serves the purposes of extending gasoline supplies, and as an octane enhancer, it replaces metallic-based additives.
- The programs are designed to reduce a country's dependence on costly imported fuel and to assist in creating a new domestic fuel industry. The production and use of bioethanol can indirectly serve a variety of needs. On a national level, bioethanol can improve balance of payments by displacing imported petroleum with domestically produced fuel. This may also provide increased rural employment and alternative markets for agricultural commodities.
- Bioethanol has a cleansing effect that removes rust and other unwanted contaminants that may have accumulated in the tank and fuel system over the years. Once the fuel system has been cleaned, the car performs better and more efficiently.

Mr. Vice Chancellor Sir, I have worked on different agrowastes for conversion of this wastes to bioethanol using microorganisms in the hydrolysis and fermentation e.g. Rice husk, maize husk, Guinea corn shaft, water hyacinth, saw dust, yam peels, effluent from abattoir, cassava peels, sweet potatoes peels, among others etc. (Oyeleke and Jibrin, 2009, Oyeleke *et al.*, 2009).

(v) Butanol

Butanol is often claimed to provide a direct replacement for gasoline, because it can be used directly in a gasoline engine (in a similar way to biodiesel in diesel engines). It is not in widespread production, and engine manufacturers have not made statements about its use. While on paper (and in few lab tests) it appears that butanol has sufficiently similar characteristics with gasoline such that it should work without problem in any gasoline engine, no widespread experience exists. Butanol is formed by ABE fermentation (acetone, butanol, ethanol) and experimental modifications of the process show potentially high net energy gains with butanol as the only liquid product. Butanol will produce more energy and allegedly can be burned "straight" in existing gasoline engines (without modification to the engine or car) (EEA), 2006), (European Environment Agency), and is less corrosive and less water soluble than ethanol, and could be distributed via existing infrastructures.

(vi) Biomethanol

Methanol (CH_3OH) is currently produced from natural gas, a fossil fuel. It can also be produced from biomass like sawdust of Japanese cedar, (*Cryptoria japonica*), back of Japanese cedar, chipped Japanese larch (*Larix leptolepis*), bamboo (*Phyllostachys pubescens*), salix (*Salix sachalinensis* and *S. pet-susu*), cut waste wood, sawn wood and demolition waste (raw materials from particle board), the plant of sorghum (Sorghum bicolor), rice bran (*Oryza sativa cv. Koshihikari*), straw (*cv. Yumehitachi* and husks (*cv. Koshihikari*) of rice and other lignocelluloses wastes. These biomass are converted into powdery form and put in a boiler for gasification into methane (natural gas), Purified methane (CH_4) is cracked with steam in steam reformer using a nickel catalyst at high temperature (>500°C). The methane and steam splits into syngas, a mix of H_2, CO_2 and CO. The syngas is cooled and compressed to around 100bar, with the separate components reacting in a synthesis reactor to produce methanol. It is safer and environmentally friendly. Although toxic it is less toxic than petrol. The use of methanol will provide a good alternative to fossil fuel since it will only need a slight modification of filling station and motor vehicle engines (Chemical technology.com 2011 Net resources). The principle of methanol synthesis by the C_1 chemical transformation technology is as follows:

Gasification (Partial oxidation) — Methanol synthesis (With catalyst)

Carbohydrates $\xrightarrow{1000^{0}C}$ Mixture of gases $\xrightarrow{\text{Pressure (40-80atm)}}$ Biomethanol

$CO + 2H_2 \quad CH_3OH$

$(CH_20)_n$ Pretreatment H_2

+

0_2 Dry crush into $C0$

$+ H_20$ Powder $C0_2$

H_20

(vii) Biogas

Methane (CH_4) is a gas made up of a molecule of carbon and four molecules of hydrogen. It is the major component of the "natural" gas used in many homes for cooking and heating. It is odorless, colorless, and yields about 1,000 Btu [252 kilocalories (kcal)] of heat energy per cubic foot (.028 cubic meters) when burned. Natural gas is a fossil fuel that was produced years ago by the anaerobic decomposition of organic materials. It is often found in association with oil and coal (Sokoto Energy Research Centre (SERC), 1994).

The same types of anaerobic bacteria that produced natural gas also produce methane today. Anaerobic bacteria are some of the oldest forms of life on earth. They evolved before the photosynthesis of green plants released large quantities of oxygen into the atmosphere. Anaerobic bacteria break down or "digest" organic material in the absence of oxygen and produce "biogas" as a waste product. (Aerobic decomposition, or composting, requires large amounts of oxygen and produces heat.) Anaerobic decomposition occurs naturally in swamps, water-logged soils and rice fields, deep bodies of water, and in the digestive systems of termites and large animals. Anaerobic processes can be managed in a "digester" (an airtight tank) or a covered lagoon (a pond used to store manure) for waste treatment. The primary benefits of anaerobic digestion are nutrient recycling, waste treatment, and odor control. Except in very large systems, biogas production is a highly useful but secondary benefit (Lawal *et al.*, 2001).

Biogas produced in anaerobic digesters consists of methane (50%-80%), carbon dioxide (20%-50%), and trace levels of other gases such as hydrogen, carbon monoxide, nitrogen, oxygen, and hydrogen sulfide. The relative percentage of these gases in biogas depends on the feed material and management of the process. When burned, a cubic foot (.028 cubic meters) of biogas yields about 10 Btu (2.52 kcal) of heat energy per percentage of methane composition. For example, biogas composed of 65% methane yields 650 Btu per cubic foot (5,857 kcal/cubic meter).

As long as proper conditions are present, anaerobic bacteria will continuously produce biogas. Minor fluctuations may occur that reflect the loading routine. Biogas can be used for heating, cooking, and to operate an internal combustion engine for mechanical and electric power. For engine applications, it may be advisable to scrub out hydrogen sulfide (a highly corrosive and toxic gas). Very large-scale systems/producers may be able to sell the gas to natural gas companies, but this may require scrubbing out the carbon dioxide.

Factors that affect the rate of digestion and biogas production

A variety of factors affect the rate of digestion and biogas production. The most important is temperature. Anaerobic bacteria communities can endure temperatures ranging from below freezing to above 57.2°C, but they thrive best at temperatures of about 36.7 °C (mesophilic) and 54.4 °C (thermophilic). Bacteria activity, and thus biogas production, falls off significantly between about 39.4 and 51.7°C and gradually from (35 to 0°C).

In the thermophilic range, decomposition and biogas production occur more rapidly than in the mesophilic range. However, the process is highly sensitive to disturbances such as changes in feed materials or temperature. While all anaerobic digesters reduce the viability of weed seeds and disease-producing (pathogenic) organisms, the higher temperatures of thermophilic digestion result in more complete destruction. Although digesters operated in the mesophilic range must be larger (to accommodate a longer period of decomposition within the tank [residence time]), the process is less sensitive to upset or change in operating regimen.

To optimize the digestion process, the digester must be kept at a consistent temperature, as rapid changes will offset bacterial activity. In most areas of the United States, digestion vessels require some level of insulation and/or heating. Some installations circulate the coolant from their biogas-powered engines in or around the digester to keep it warm, while others burn part of the biogas to heat the digester. In a properly designed system, heating generally results in an increase in biogas production during colder periods. The trade-offs in maintaining optimum digester temperatures to maximize gas production while minimizing expenses are somewhat complex. Studies on digesters in the north-central areas of the country indicate that maximum net biogas production can occur in digesters maintained at temperatures as low as 72°F (22.2°C).

Other factors affecting the rate and amount of biogas output include pH, water/solids ratio, carbon/nitrogen ratio, mixing of the digesting material, the particle size of the material being digested, and retention time. Pre-sizing and mixing of the feed material for a uniform consistency allows the bacteria to work more quickly. The pH is self-regulating in most cases. Bicarbonate of soda can be added to maintain a consistent pH, for example when too much "green" or material high in nitrogen content is added. It may be necessary to add water to the feed material if it is too dry, or if the nitrogen content is very high. A carbon/nitrogen ratio of 20/1 to 30/1 is best. Occasional mixing or agitation of the digesting material can aid the digestion process. Antibiotics in livestock feed have been known to kill the anaerobic bacteria in digesters. Complete digestion, and retention times, depends on all of the above factors (Aliyu, 1994).

Using the effluent

The material drawn from the digester is called sludge, or effluent. It is rich in nutrients (ammonia, phosphorus, potassium, and more than a dozen trace elements) and is an excellent soil conditioner. It can also be used as a livestock feed additive when dried. Any toxic compounds (pesticides, etc.) that are in the digester feedstock material may become concentrated in the effluent. Therefore, always test the effluent before using it on a large scale (Tambuwal *et al.*, 1997).

Economics consideration in biogas production

Anaerobic digester system costs vary widely. Systems can be put together using off-the-shelf materials. There are also a few companies that build system components. Sophisticated systems have been designed by professionals whose major focus is research, not low cost. Factors to consider when building a digester are cost, size, the local climate, and the availability and type of organic feedstock material.

Alternate feedstocks

Animal wastes are generally used as feedstock in biogas plants and their potential for biogas production is given in Table 1. But, the availability of these substrates is one of the major problems hindering the successful operation of biogas digesters. Khendelwal, (1990), reported that the availability of cattle waste can support only 12–30 million family-size biogas plants against the requirement of 100 million plants. A significant portion of 70–88 million biogas plants can be run with fresh/dry biomass residues. Of the available 1,150 billion tons of biomass, a fifth would be sufficient to meet this demand (Jagadeesh, 1996).

Table 1: Potential biogas production from different feedstocks (Khendelwal, 1990)

Feedstock	*Availability (kg animal-1d-1)*	*Gas yield (m3kg-1)*
Cattle waste	10	0.36
Buffalo waste	15	0.54
Piggery waste	2.25	0.18
Chicken waste	0.18	0.011
Human excreta	0.4	0.028

Many workers have explored various substrates for biogas production. For biogas production, the two most important parameters in the selection of particular plant feed stocks are the economic considerations and the yield of methane for fermentation of that specific feedstock (Smith *et al.*, 1992, Oyeleke and Jibrin 2009, Oyeleke *et al.*, 2009).

SECOND GENERATION BIOFUEL

Second generation biofuel production processes use non-food crops. These include the stalks of wheat and corn, wood, special energy or biomass crops (e.g. Miscanthus) and waste biomass (Oyeleke and Jibrin 2009, Oyeleke *et al.*, 2009). These processes could utilize the waste products of current food-based agriculture to manufacture fuel sustainably. Second generation biofuel processes are in development: pilot plants are established for the production of ethanol from wheat straw and diesel from wood chippings. It is important to note that carbon in waste biomass is used by other organisms, e.g. it is broken down in the soil to produce nutrients, and provides a habitat for wildlife. The large scale use of such "waste" biomass by humans might threaten these habitats and organisms.

BIOFUELS IN DEVELOPING COUNTRIES

Mr. Vice Chancellor Sir, Biogas development efforts in Nigeria dates back to the

1970s. Since then, more biogas plants have been put in place at (i) village pioneer project in Ajue near Ondo State (ii) the agricultural technology research farm at Obafemi Awolowo University (OAU), Ile Ife (iii) Government House Annex and State Hospital, Osogbo, Osun State (iv) the biogas plants of Sokoto Energy Research Centre, Sokoto State (v) the Biogas plant at Federal Institute of Industrial Research, Oshodi (FIIRO), (vi) the floating gas holder and fixed dome plants at Ojokoro, Lagos constructed by FIIRO and Sokoto Energy Research Centre (Lawal *et al.*, 2001), Biogas generating plant in ten Local Government Areas of Kastina, Kastina State.

Biofuel industries are becoming established in many developing countries. Many developing countries have extensive biomass resources that are becoming more valuable as demand for biomass and biofuels increases (Oyeleke *et al.*, 2009). The approach to biofuel development in different parts of the world varies. Countries such as India and China are developing both bioethanol and biodiesel programs. India is extending plantations of *Jatropha*, an oil-producing tree that is used in biodiesel production. The Indian sugar ethanol program sets a target of 5% bioethanol incorporation into transport fuel. (ethanol India website). China is a major bioethanol producer and aims to incorporate 15% bioethanol into transport fuels by 2010.Nigeria has incorporated 10% ethanol into its fuel as approved in 2009 by the late president and commander in chief, Alh Musa Yaradua of blessed memory.

Amongst rural populations in developing countries, biomass provides the majority of fuel for heat and cooking. Wood, animal dung and crop residues are commonly burned. Figures from the International Energy Agency show that biomass energy provides around 30% of the total primary energy supply in developing countries; over 2 billion people depend on biomass fuels as their primary energy source. World resources institute document on wood fuels, 2008.

The use of biomass fuels for cooking indoors is a source of health problems and pollution. 1.3 million deaths were attributed to the use of biomass fuels with inadequate ventilation by the International Energy Agency in its World Energy Outlook 2006. Proposed solutions include improved stoves and alternative fuels. However, fuels are easily damaged, and alternative fuels tend to be expensive. People in developing countries are unlikely to be able to afford to put these solutions in place. Organizations such as Intermediate Technology Development

Group work to make improved facilities for biofuel use and better alternatives accessible to those who cannot get them.

CURRENT ISSUES IN BIOFUEL PRODUCTION AND USE

Mr. Vice Chancellor Sir, Biofuels can provide benefits including: reduction of greenhouse gas emissions, reduction in the use of fossil fuel importation and used, increased national energy security, increased rural development and a sustainable fuel supply for the future (Marshall, 2007).

However, biofuels have limitations. The feed stocks for biofuel production must be replaced rapidly and biofuel production processes must be designed and implemented so as to supply the maximum amount of fuel at the cheapest cost, while providing maximum environmental benefits. Broadly speaking, first generation biofuel production processes cannot supply us with more than a few percent of our energy requirements sustainably. Second generation processes can supply us with more biofuel, with better environmental gains. The major barrier to the development of second generation biofuel processes is their capital cost: establishing second generation biodiesel plants has been estimated at €500million Nexant Chem Systems study.

ALGAE AS BIOFUEL

The use of algae as biofuel has generated a new dimension in the production of biofuel. One of the advantages of using algae for biofuel is the ease of algae mass cultivation by using any water types. Algae are groups of plant mostly adapted to aquatic habitats. The cellular construction of algae maybe simple unicellular to large multicellular eukaryotes. Algae play a major role in the functioning of the ecosystem or food chain. .In the production of biofuel large cultivation of algae or algaculture is carried out in various region of the world. The important fuel synthesize from algae are vegetable oil, biogas, biodiesel, biomethanol, bioethanol (Fig 6), biobutanol, and dry fuel (similar to charcoal). Many countries have implemented the use of algae with very highly sophisticated techniques for enhancing mass scale cultivation of algae (Fig 7).

Fig 6: Consortium of algae

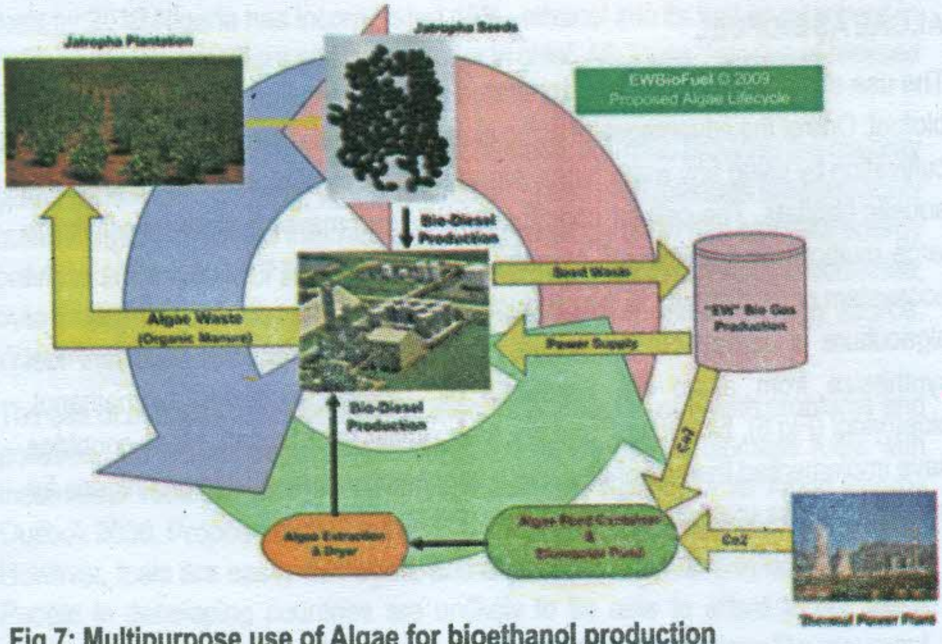

Fig 7: Multipurpose use of Algae for bioethanol production

ENERGY EFFICIENCY AND ENERGY BALANCE OF BIOFUELS

Production of biofuels from raw materials requires energy (for farming, transport and conversion to final product as well as the production of fertilizers, pesticides and herbicides). The level of energy expenditure varies by location: more intensive agricultural regimes such as those found in Western countries are more energy intensive. The more machinery is used for farming, the greater the energy expended in the process; developing countries tend to have less intensive agricultural methods. It is possible to produce biomass without incurring large agricultural energy costs: for example, wild-harvesting excess wood from established forests can be done without much energy input. However the yield of biomass from such resources is not consistent or large enough to support biofuel manufacture on a large scale.

The energy balance of a biofuel is determined by the amount of energy put in to the manufacture of fuel compared to the amount of energy released when it is burned in a vehicle. Biofuels tend to require higher energy inputs per unit energy than fossil fuels: oil can be pumped out of the ground and processed more efficiently than biofuels can be grown and processed. However, this is not necessarily a reason to use oil instead of biofuels, nor does it have an impact on the environmental benefits provided by a given biofuel.

Other factors connected to energy balance are a) cost and b) environmental impact. High energy impacts do not necessarily mean that the resulting fuel will be bad for the environment: energy can be derived from renewable resources to power biofuel manufacture.

Energy balance is not necessarily a measure of a good biofuel. Biofuels should be affordable, sustainable, and abundant to provide good Green House Gas emissions savings when compared with fossil fuels. Energy balance/ efficiency of conversion is relevant when considering how best to use a given amount of biomass resources. For example, given limited resources should biomass be converted into heat and power or liquid transport fuels? Looking at energy balance and the efficiency of energy conversion can help to use biomass resources efficiently and with maximum environmental gain.The energy balance is more favourable for biofuels made from crops grown in subtropical or tropical areas than those made from crops grown in temperate areas. This is largely due to the increased yield of biomass from crops in areas that receive more sunlight.

Life cycle assessments [LCA] of biofuel production show that under certain circumstances, biofuels produce only limited savings in energy and greenhouse gas [GHG] emissions. Fertilizer inputs and transportation of biomass across large distances can reduce the GHG savings achieved. The location of biofuel processing plants can be planned to minimize the need for transport, and agricultural regimes can be developed to limit the amount of fertilizer used for biomass production. A European study on the greenhouse gas emissions found that well-to-wheel (WTW) CO_2 emissions of biodiesel from seed crops such as rapeseed could be almost as high as fossil diesel. It showed a similar result for bio-ethanol from starch crops, which could have almost as many WTW CO_2 emissions as fossil petrol. This study showed that second generation biofuels has far lower WTW CO_2 emissions. Other independent LCA studies show that biofuels save around 50% of the CO_2 emissions of the equivalent fossil fuels. This can be increased to 80-90% GHG emissions savings if second generation processes or reduced fertilizer growing regimes are used (Concawe Well to Wheels LCA for biofuels).

ENVIRONMENTAL EFFECTS

Most mainstream environmental groups support biofuels as a significant step toward slowing or stopping global climate change. However, biofuel production can threaten the environment if it is not done sustainably. Biofuels produce greenhouse gas emissions during their manufacture. The sources of these emissions are: fertilizers and agricultural processes, transportation of the biomass, processing of the fuels, and transport and delivery of biofuels to the consumer. Some biofuel production processes produce far fewer emissions than others; for example sugar cane cultivation requires fewer fertilizer inputs than corn cultivation, therefore sugar cane bioethanol reduces greenhouse gas emissions more effectively than corn derived bioethanol. However, given the appropriate agricultural techniques and processing strategies, biofuels can provide emissions savings of at least 50% when compared to fossil fuels such as diesel and petroleum.

The increased manufacture of biofuels will require increasing land areas to be used for agriculture. Second generation biofuel processes can ease the pressure on land, because they can use waste biomass and existing (untapped) sources of biomass such as crop residues and potentially even marine algae.

In some regions of the world, a combination of increasing demand for food, and increasing demand for biofuel, is causing deforestation and threats to biodiversity. The best reported example of this is the expansion of oil palm plantations in Malaysia and Indonesia, where rainforest is being destroyed to establish new oil palm plantations. It is an important fact that 90% of the palm oil produced in Malaysia is used by the food industry (Malaysian Palm Oil Council 2008); therefore biofuels cannot be held solely responsible for this deforestation. There is a pressing need for sustainable palm oil production for food and fuel industries; palm oil is used in a wide variety of food products. The Roundtable on Sustainable biofuels is working to define criteria, standards and processes to promote sustainably produced biofuel (Doraisamy *et al.*, 1989). Palm oil is also used in the manufacture of detergents, and in electricity and heat generation both in Asia and around the world (the UK burns palm oil in coal-fired power stations to generate electricity).

Significant area is likely to be dedicated to sugar cane in future years as demand for ethanol increases worldwide. The expansion of sugar cane plantations will place pressure on environmentally-sensitive native ecosystems including rainforest in South America (Kalaichelvan, 1997). In forest ecosystems, these effects themselves will undermine the climate benefits of alternative fuels, in addition to representing a major threat to global biodiversity (Mackie and Abryant, 1981). Although biofuels are generally considered to improve net carbon output, biodiesel and other fuels do produce local air pollution, including nitrogen oxides, the principal cause of smog.

POLITICS

Mr. Vice Chancellor Sir, the Biofuels Progress Report (Brussels, [9.1.2007] COM(2006) 845 final) from the Commission has stated that it doesn't expect the biofuels target of 10 % to be met in 2015. The average member state achieved 52% of its target in 2005 where only 2 member states met their target of 2% biofuels in the national mix. Although biofuels are not the most cost effective fuel when economic crops are used, however agro waste has proved to be very useful in this regard. The use of biofuel is only a practical means for reducing the EU's dependence on oil. It should be said that the production of biofuels does not automatically equate in CO_2 savings as it depends on the land management employed. If the energy crop has replaced natural rain forest the effects would be negative not only on CO_2 sequestration but also on native biodiversity and habitat areas. However the use of agrowaste has provided us a safer means of production. Responsible bioethanol production can provide diversification of energy supply and energy security while also creating employment in the many process jobs involved in the industry. Further actions to reduce emissions in the EU were reinforced by the European Commission's call for vehicle manufactures to reduce car CO_2 emissions to 120g/km by 2012 from 2004 levels of 163g/km 2. The role of bioethanol for transport fuels could also make an important impact on CO_2 reduction from transport. The technology side is seen as a critical area for reducing transport CO_2 as it is acknowledged that mobility, in the EU, will certainly not decrease but increase with time.

CONCLUSION

Despite the exciting prospects for bioenergy, many important questions remain unresolved about its implications for the masses (poor), the environment, and international trade. However, because most of the environmental and social benefits and costs of bioenergy are not priced in the market, leaving bioenergy development entirely to the private sector and the market will lead to bioenergy production and processes that fail to achieve the best environmental and social outcomes. To ensure better outcomes, the public sector has important roles to play. But what are these roles, and what policies, technologies, and investments are needed to ensure that bioenergy is developed in ways that are economically efficient as well as compatible with reducing poverty and global warming? This researches attempts to answer these questions, with a special focus on the issues for developing countries. The researches also analyze the potential trade-offs between bioenergy production and food in terms of food prices, explore some of the technology options like the use of agro wastes as research priorities for the future, and discuss ways in which carbon payments schemes might be harnessed to promote bioenergy production.

SUMMARY

Energy is the source of economic growth of any nation. Energy consumption reflects the state of development of a nation. Fossil fuels like coal, gas, and oil are exhaustible, nuclear energy has its own limitation and non-conventional energy such as wind power, tidal and solar are not sufficiently exploited. Bioenergy has proven to be a practical approach to obtain cheap, clean to use and unlimited source of energy. Waste conversion to energy concept is now accepted as attractive/alternative proposal, particularly with the biotechnological progress in improving the efficacy of microorganisms that are involved in bioreactors used as control in the processes. It is not the energy production for distribution and use; rather it is to save energy expenditure on waste treatment and to meet part of the attention as a sustainable energy source that may help cope with rising energy prices and the needs to address environmental concerns about greenhouse gas emissions. Bioenegy offers a new income and employment generation to farmers and rural communities around the world. For many countries in the Organization for Economic Cooperation and Development (OECD), the benefits to farmers are also perceived as a good way to reduce the costs and market distortions of their existing farm support and the overhead cost.

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