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RESEARCH ARTICLE

BIOFUELS AND SUSTAINABLE DEVELOPMENT

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ABSTRACT

Biofuels are gaining increased public and scientific attention, driven by factors such as need for increased energy security, concern over greenhouse gas emission from fossil fuels, oil price hikes, has finally lead the search to sustainable alternatives. Biofuel has become an alternative with great promise with quite some problems to contend with; this includes the development of feasible technologies in recent years such as the search for highly efficient saccharification enzymes; and high cost of production which makes the price of biofuel expensive. Lots of progress on biofuel development and efficient technologies being developed for its production were reviewed.

Key words: Biofuels, Development, Production.

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INTRODUCTION

The term biofuel refers to gaseous and liquid fuels for transport sector that are predominantly produced from biomass. It is generally held that biofuels offer various benefits, including sustainability, reduction of greenhouse gas emissions and security of supply (Rejinders, 2006). In developing countries there is a growing trend towards employing modern technologies and efficient bio energy conversion using a range of biofuels which are becoming cost competitive with fossil fuels (Puhan *et al*., 2005). Various scenarios have put forward estimates of biofuel from biomass sources in the future energy system. In the most biomass-intensive scenario, by 2050 modernised biomass energy will contribute about one half of the total energy demand in developing countries (IPCC, 1997). Despite enthusiastic views on potential of biofuels for sustainable development, there is currently very little research on the links between biofuel production and sustainable development. Existing Research focuses on biofuel production and sustainable development.

Renewable energy as an alternative fuel: Due to the lack of sustainability of non –renewable energy, the demand for renewable energy source has increased which include; solar energy, wind, geothermal, bioenergy (biomass) etc. (Stevens and Verch, 2004). Developing countries such as Brazil, India are considered to be the great source for the renewable energy due to the increased demands of rapid industrialization and high population (Kohli *et al*., 2009).

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Tremendous amount of energy is consumed by industrial commercial and transport sectors. The CO_2 emission from transportation sector is the major contributor to environmental pollution.

Biofuels: Biofuel is fuel produced from renewable biological resources such as plant biomass and treated municipal and industrial waste for the purpose of generating heat, electricity and fuel for transport, industry, agriculture, and households. First generation biofuels are produced from fermentation of sugar & starch and biodiesel from edible oil seeds. Second generation biofuels are biofuels are bioethanol from lingo cellulosic biomass, produced from non-edible parts .Third generation biofuels are produced from microalgae & cyanobacteria; bio hydrogen &bioelectricity generation using photosynthetic methods can be considered as 4th generation biofuels (Gouveia and Olivera, 2009). lots of process for the production of bioethanol from lignocellulosic biomass are being developed; this includes enzymatic hydrolysis and fermentation process and gasification (Piccolo and Benzzo 2008), the wastes that are used for bio ethanol production are classified into 3 groups according to the pre-treatment process in sugar, starchy, lignocellulosic biomass. Bioconversion of lignocellulosic biomass is significantly hindered by the structural and chemical complexity of biomass, which makes these materials a challenge to be used as feedstock for cellulosic ethanol production. Cellulose and hemi cellulose, when hydrolysed into their component sugars, can be converted into ethanol through well-established fermentation technologies.

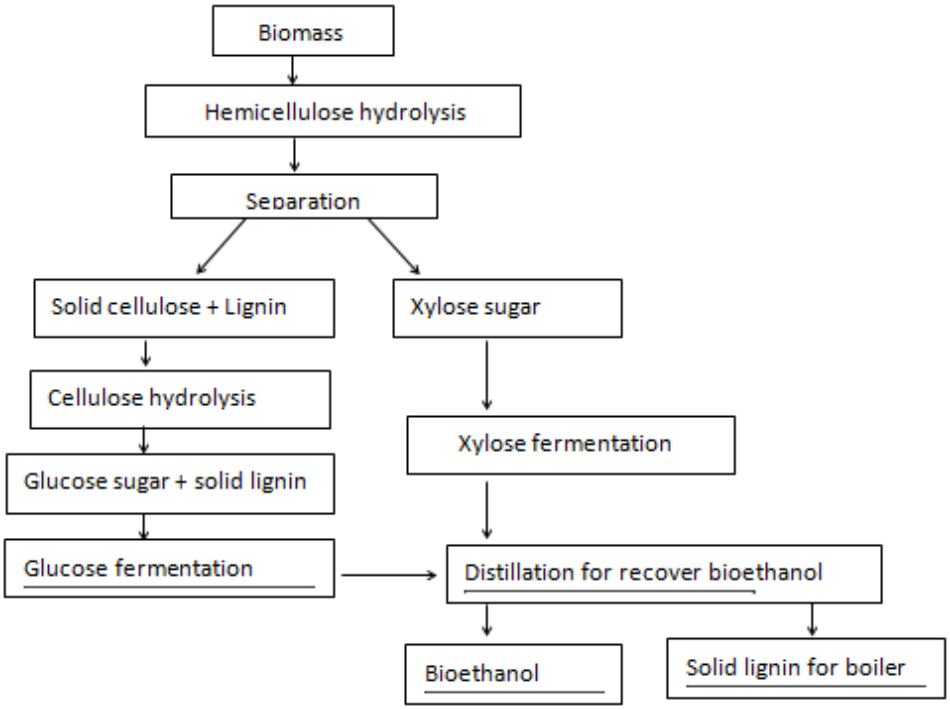

Figure 1. Flow chart for production of bio-ethanol from lignocellulosic biomass materials

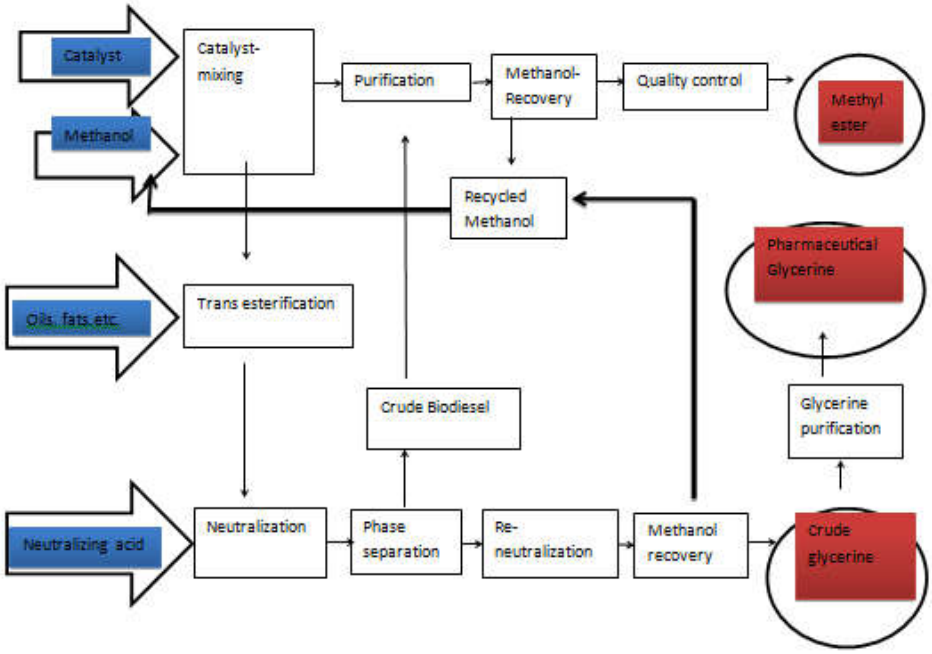

Figure 2. Flow chart for production of bio-diesel using transesterfication process

Generally there are three steps for bio ethanol production from lignocellulosic biomass while taking conventional method into consideration (i) Pre-treatment (commonly acid or enzyme hydrolysis) (ii) fermentation, (iii) distillation. Pre-treatment step converts lignocellulosic biomass from its native form .pre-treatment method can be classified into three categories, including physical, chemical, and biological treatment. In this step, biomass structure is broken to fermentable sugars. In fermentation step there are a series of chemical or enzymatic reactions is caused by yeast or bacteria, which feed upon the sugar such as saccharomycescerevisae. In distillation step, the pure ethanol is separated from the mixture using distiller which boils the mixture by heater or evaporates the mixture to the condensate at top of the apparatus to produce the ethanol from joined tube.

Figure 1 shows Flow chart for production of bioethanol. Bioethanol is made from glucose created in green plants by the sun, the so called photosynthesis;

(A) $6CO_2 + 6H_2O$ +sunshine $\longrightarrow$ $C_6H_{12}O_6+6O_2$

Sun energy transforms carbon dioxide into glucose .the glucose is transformed to ethanol (C_2H_6O) by classic yeast fermentation

(B) $C_6H_{12}O_6 \longrightarrow 2C_2H_6O + 2CO_2$

Heat is released calling for cooling after fermentation vessels and heat is released again when ethanol is burned in the combustion engine.

(C) $C_2H_6O+3O_2 \longrightarrow 2CO_2 + H_2O + Heat.$

Here the only CO_2-absorbed during the photosynthesis-and no more is released by the engine. This also explains why bioethanol is considered as a form of solar energy. All the CO_2 and water absorbed by the green plants are again released. The United States produced the greatest amount of bioethanol in the world generating some 15.8 billion gallons in total (Table 2). Biodiesel is a clean burning diesel fuel produced from vegetable oils, animal fats, or grease. Because of its origin from renewable resources, it is more likely that it competes with petroleum products in the future. Commercially biodiesel is produced by transesterification of triglycerides which are the main ingredients of biological origin oils in the presence of an alcohol (e.g. methanol, ethanol) and a catalyst (e.g. alkali, acid, enzyme) with glycerine as a major by- product (Ma and Hanna, 1999; Dube *et al*., 2007). After the reaction, the glycerine is separated by settling or centrifuging and the layer obtained is purified prior to using it for its traditional applications. Figure 2 shows Flow chart for production of bio-diesel using transesterfication process.

Stage 1:
$TGE + CH_3OH \xleftrightarrow{\text{Catalyst, K1}} DGE + R_1COOCH_3$

Stage 2:
$DGE + CH_3OH + R_2COOCH_3 \xleftrightarrow{\text{Catalyst, K2}} MGE$

Stage 3:
$MGE + CH_3OH + R_3COOCH_3 \xleftrightarrow{\text{Catalyst ,K3}} GL +$

Overall then,
$TGE + 3\ CH_3OH \xleftrightarrow{\text{Catalysts, Keq}} RCOOH_3 + GL$

Where DGE, MGE, & TGE are di glyceride, mono glyceride & triglyceride esters respectively. GL is the glycerol produced & K1, K2, & K3 are equilibrium constants for stages 1 to 3 respectively. Keq is the overall equilibrium constant. The United States and Brazil were among the largest biodiesel producers in the world, totalling some 06 and 4.3 billion litres respectively, in 2017 (Table 3).

Table 1. Leading countries based on biofuel production in 2017

Country	(1000 Metric tons of Oil)
United States	36936
Brazil	18465
Germany	3293
Argentina	3131
Indonesia	2326
France	2224
China	2147
Thailand	1846
Netherland	1658
Canada	1239

Source: Statista 2018

Biotechnology in Biofuel Production: n of the expresses enzymes in the bio conversion process. Significant improvement has been made with the help of molecular biology in past few decades to improve the microbial activity and enzymes. Biotechnology uses eye catching way of producing biofuel which increases the yield without much increase in the energy needed for production. The use of genetically modified organisms (GMOS) is found to be efficient and quick method to improve biofuel conversion particularly in case of lignocellulosic biomass with the help of biotechnology, structure of cell wall and composition of lignocellulosic in plant cell can be modified to enhance ethanol yield per acre. With the help of biotechnology, structure of cell wall and composition of lignocellulosic in plant cell can be modified to enhance ethanol yield per acre. Biotechnology can influence yield density by varying plant physiology, their architecture, along with their photosynthetic efficiency and it has also shown its ability to lessen agronomic inputs for instance herbicide and pesticides. Biotechnology is considered as an efficient means of biofuel production and enhancing the yields of biofuels by removing the current of bottle neck such as poor yield, toxins and improving agronomic traits of crops (Lynd *et al*., 2008). For biodiesel crops like Jatropa, Curcus, toxicity and high amount of free fatty acids limit their full potential; these and other problems can be solved using molecular approaches. Research has already been carried out successfully for the cloning of genes that code for Cellulases and polyglavcturonase enzymes to develop low cost effective bio refinery strategy to achieve maximum biomass conversion and improved gas chromatography-mass spectrophotometry method that has been developed by researchers at TAMUK in understanding the catalytic action.

Table 2. Leading countries based on Bioethanol production in 2017

Country	Million gallons
United States	15800
Brazil	7060
European Union	1415
China	875
Canada	450
Thailand	395
Argentina	310
India	280

Source: Statista 2018

Table 3. Leading countries based on bio diesel production in 2017

Country	Billion Litres
United States	6
Brazil	4.3
Germany	3.5
Argentina	3.3
China	1
France	2.3
Thailand	1.4
Indonesia	2.5
Canada	0.5
Netherland	0.4
Spain	1.3

Source: Statista 2018

Potential of Biofuels: Bioethanol and biodiesel are the two biofuels that are commercially produced. There is tremendous potential for second generation biofuels in India, especially for cellulosic and agricultural crop residues. The biofuel policy of Indiahas an indicative target of 20 per cent blending of bioethanol by 2017. India has 330 distilleries, which can produce more than 04 million litres of rectified spirit (alcohol) per year in addition to 1.5 billion litres of fuel ethanol which could and should meet the requirement of 5% blending. Due to the increasing demand, the market for biofuel in general & biodiesel is large .Germany and France use rape seed oil for biodiesel production. Scientists are considering biodiesel production from green algae and bacteria using genetic engineering techniques (Kohli *et al.,* 2009). A recent research concluded that by 2050, biofuel theoretically could supply

65% of the world's current energy consumption, with sub-Saharan Africa, the Caribbean and Latin America accounting for roughly half of this global potential.

Conclusion

Biofuel is a good replacement for fossil fuels (non-renewable) and with mentioning economical, safety and environmental reasons it is so crucial. Besides it produces less amount of CO_2 in comparison to fossil fuels. It produces fewer pollutants which is a good help to the structure of nature and stability of environment which is at risk. Global biofuel production has increased from 9.2 million metric tons of oil equivalents in 2000 to 84.12 million metric tons of oil equivalent in 2017. The current technologies available for biofuel production should be improved by funding and ensuring reliable research globally. Collective approach involving enhanced government policies, industrial and farmer's participation is necessary. Emphasis should always be given to non-edible crops and pre-exploited agricultural land to avoid food storage and environmental degradation. Growth in the biofuel market will partly reduce import dependence on crude oils and encourage optimal use of other renewable energy resources, particularly when strong economic growth prospects drive higher demand for gasoline and petroleum products.

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