WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Bioenergy: The Need of The Hour: A Review

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1. Introduction

Our lives would come to a standstill from the lack of electricity. Our computers would not work, nor would our vehicles all while we would be dealing with loss of fans, heaters and light bulbs. For those living in cities, energy is generally sourced from thermal power plants. Coal is burned as fuel to generate heat which is used to boil water and generate steam, which rotates the blades of a turbine connected to an electric current generator. In an analysis by CSE (Centre for Science and Environment), Delhi, in October 2020, the Delhi government sources 33.6 per cent of its total power needs from coal-based thermal power plants (TPP) that do not meet emission norms for particulate matter, sulphur dioxide and oxides of nitrogen as stipulated by the Environment Protection Act, 1986. The rest is obtained from thermal plants placed in the yellow or orange zones in terms of harmful emissions. Alternate energy sources will have to be found, when we can no longer rely on coal or global warming reaches its extremely critical levels.

Bioenergy is a clean, sustainable form of energy that presents a possible solution. It is not new, wood is one form of biofuel that has been used since ancient times. Biogas plants, biomass briquettes, biodiesel and hydrogen generated from biomass are some of the modern forms of this energy.

1.1 What is Biofuel?

Biofuel is any fuel that is derived from biomass— plant or algae material or animal waste without involving geological processes (like that in the formation of fossil fuels: petroleum and coal).

Since such feedstock material can be replenished and is readily available, biofuel is considered to be a source of renewable energy unlike petroleum, coal, and natural gas. It is produced from renewable feedstocks such as sugar cane and sugar beet, starch crops like corn and sorghum, oilseed crops and animal fats. Examples of biofuel include ethanol, biodiesel, green diesel and biogas. Biofuel can be solid, liquid, or gaseous.

Biofuel is considered a cost-effective and environmentally friendly alternative to petroleum and other fossil fuels in the scenario of rising petroleum prices and increasing contribution of fossil fuels to global warming.

1.2 Examples of Biofuels

1.2.a. Methane, or swamp gas is formed by bacteria engaged in the decomposition of fertilizer, sewage, or solid plant waste such as banana peels or corn stalks. This is especially useful in rural farmlands is the principle behind biogas plants. Methane gas can be stored and used as a supplement for propane and natural gas. Methanol has a chemical makeup that is similar to methane, the difference being that methanol is a liquid generally and methane is a gas. Methanol is used similarly.

1.2.b. Alcoholic Biofuels: Starchy plants like sugar beets, maize, and sugar cane can be processed into alcohol biofuels. Fungi and bacteria turn the plant content into alcohol through fermentation. The process of converting biomass to methanol or ethanol at high temperature in presence of a catalyst is called gasification.

1.3.c. Biodiesel: environment-friendly biodiesel is made from many natural vegetable oil sources, among them animal fats and herbal oils. Oil waste from factories and restaurants is also repurposed into biodiesel.

1.2.d Wood This is the most general type of biofuel. Dry Wooden branches are collected and used as fuel to make food and power tiny household gadgets.

1.3 Applications of Biofuels

1.3.a. Transportation: Almost a third of all biofuel is being used as fuel in cars and trucks. Biodiesel can be used neat or as a diesel additive and is typically used as a fuel additive in 20% blends (B20) with petroleum diesel in compression ignition (diesel) engines. Other blend levels can be used depending on the cost of the fuel and the desired benefits.

Biofuels are easy to transport because they are relatively energy dense (unlike electricity and batteries) and because they are easy to distribute through the current infrastructure with only minor modifications (unlike hydrogen).

1.3.b. Generating Energy and providing heat: Biofuel can be used to produce power where biowaste is easily available. Dry wood has been used as a source of heat for cooking since ancient times and is still used in several places. The problem with wood-cooking is the emission of carbon dioxide and smoke. Biofuels would help society build a clean, sustainable energy system.

1.3.c. Oil Spills and Grease: Biofuel has been tested to act as a possible cleansing agent for regions where oil has polluted the waters. Biodiesel when spread on contaminated water surface coagulates the crude oil and the residue can be easily skimmed off the surface.

1.4 Types of Biofuels

Biofuels exist in a variety of types and are used to suit a variety of energy demands. There are three common types of biofuels:

First Generation Biofuels

First-generation biofuels are one of the types of biofuels that are made from sugar, starch, or vegetable oils. They are used as popular foodstuffs, so their increased use may cause lack of food resources. Biofuels of the first generation are "original" biofuels and represent the bulk of biofuels currently in use.

Second Generation Biofuels

These types of biofuels are biofuels of the second generation because they are "greener" and are made from the organic feedstock.

Third Generation Biofuels

Biofuels made from algae are referred to as biofuels of the third generation. Algae is very promising as a biofuel because it produces high-quality and diverse fuel. Algae produce oil that is easy to refine into diesel fuel, but algae stability is poorer than other biofuels. Extremely unsaturated oils are volatile at high temperatures.

2.1 Advantages of Biofuels

- Once all required machinery has been assembled, the production process is cheap as majorly waste products are used. The manufacturing process is likely to become cheaper in the future.
- Whereas oil is a finite resource and comes from unique materials, biofuels can be produced from a broad variety of ingredients, including crop waste, manure, and other by-products. So not only are waste materials recycled, but valuable fossil fuels are saved from exhaustion.
- The generation of biofuels can be domestic, which lowers the nation's reliance on foreign resources.
- Biofuel production would also raise demand for sufficient biofuel crops, providing an economic boost to the agriculture industry.
- Even though biofuels do have carbon emissions, they are lower compared to fossil fuels. When they are burnt, they contain considerably less carbon output and fewer contaminants.
- Global economic climate would not determine the pricing of biofuels generated by a country, hence its price is likely to be more stable compared to, say, petrol and diesel.

2.2 Disadvantages of Biofuels

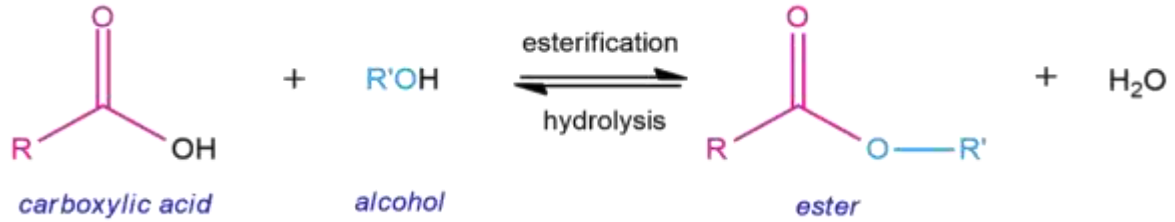
- Biofuels have a lower energy output than conventional fuels and thus more quantity of biofuel is required for generating the same amount of energy as one would get from a quantity of fossil fuel.
- Also, several experiments have been conducted to evaluate the carbon footprint of biofuels. Although they are safer to use, there are clear indicators that the fuel processing, including the equipment used to farm crops and plants to generate fuel, has high carbon emissions. The procedure of generation of biofuels has high carbon emissions which overshadows the combustion benefits of biofuels.
- Deforestation is required for the planting of biofuel generating crops like sugarcane etc. which has ramifications on global warming and affects wildlife habitat and causes species loss, reduction in natural productivity and soil erosion. Demand for ethanol derived from corn is shifting grasslands and brushlands to corn monocultures, and emphasis on biodiesel is bringing down ancient tropical forests to make way for oil palm plantations.
- The high initial investment is also needed to convert biofuels to more productive energy outputs and to develop the required processing plants to raise the volume of biofuel. Such is often not possible in rural farmlands where biofuel is in abundance.
- Croplands would be used to grow biofuels instead of food crops which may cause food shortage in rough times and increase in cost of basic subsistence. This has raised the "food vs fuel" debate.
- Biofuel providing crops require specific growing conditions, high irrigations and chemical fertilizers and pesticides.

3. A Closer Look at Biodiesel Production

The American Society for Testing and Materials defines biodiesel as a mixture of long-chain monoalkylic esters from fatty acids obtained from renewable resources, to be used in diesel engines alone or blended with fixed quantities of diesel oil. Pure Biodiesel is indicated by the symbol B100. B5 indicates a mixture of 5% Biodiesel and 95% diesel.

To produce biodiesel, vegetable or animal fats and oils are reacted with short-chain alcohols which are typically ethanol or methanol. The chemical reactions involved are transesterification and esterification. Ethanol is preferred due to availability from fermentation of biomass and its low cost. The oils used can be recycled vegetable oil (called yellow grease), fresh vegetable oil and tallow. Recycled vegetable oil requires some processing to remove dirt and food particles. A sample of the cleaned feedstock is then tested via titration against a standardized base solution to determine the concentration of free fatty acids present in the vegetable oil sample which are esterified with alcohol to produce biodiesel. A basic catalyst is used like sodium hydroxide and potassium hydroxide is used.

Animal and plant fats and oils are composed of triglycerides, which are esters formed by the reactions of three free fatty acids and the trihydric alcohol, glycerol. In the transesterification process, the added alcohol (commonly, methanol or ethanol) is deprotonated with a base to make it a stronger nucleophile.



Esterification Reaction (Image: chemistryscore.com)

Water and glycerol are produced as the by-products. Glycerol, being denser than biodiesel, is separated and used in the pharmaceutical and cosmetic industry.

Considering vegetable oils, the crops which are most frequently used are rapeseed, canola, soybean, oil palm, sunflower and peanut depending upon which is available in abundance. There are also increasing studies upon the use of non-edible oils (castor, cotton) to make biodiesel to make the process cost-efficient. From a study conducted by Martin et al., Halamphora coffeaeformis, Navicula cincta, and N. gregaria are some microalgal species with a very high oil generation capacity. These are also used as sources of oil when grown in bioreactors in large quantities.

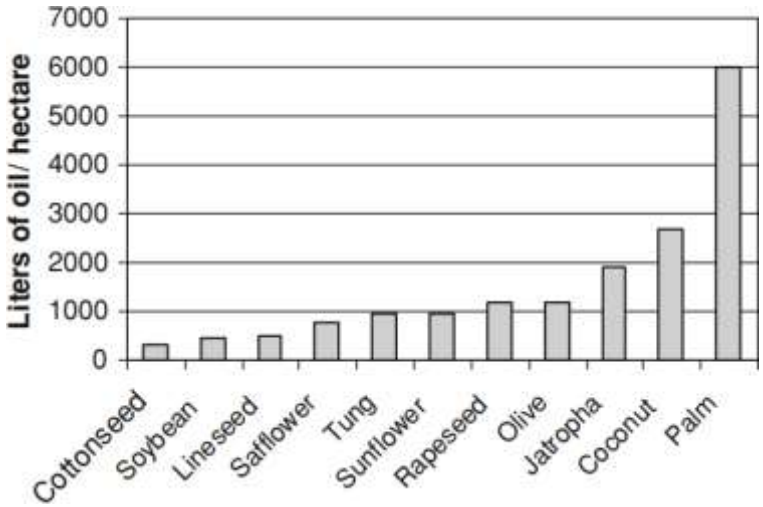


Figure 1: Yield of oil from different crops (Image Credit: Romano and Sorichetti, Springer Journal, 2011)

Conclusion

With an increasing population, the demand for energy will only increase. More fossil fuels will be used up and we will reach a point when we will have no feasible energy source. Hence, it is imperative that new energy sources are developed at an economically friendly cost. Several leaps have been made in making biomass and biofuels an energy source at par with sources which date back to the industrial age, but spreading its reach to rural areas was a matter of lack of economic facilities.

With the efforts of IARI and KVIC in India, biogas plants converting farm waste to energy and manure have proved a boon. Several governments around the world are focusing on biofuels as the next big thing in energy, creating targets for biofuel crop production and providing subsidies.

There is also the vision of the process of "Carbon Capture and Storage" through which crops would be able to perpetually remove carbon dioxide from the atmosphere as they grow and energy facilities will capture the carbon dioxide given off as biofuels burned to generate power. Captured carbon dioxide could be "sequestered" as repositories such as sediments under the sea or geological formations beneath the land.

The proper way to grow biofuels to serve all needs simultaneously will continue to be a matter of much experimentation and debate, but the fast growth in biofuel production will likely continue.

References

https://www.downtoearth.org.in/news/energy/how-clean-is-delhi-s-electricity-not-much-finds-cse- study-73919#:~

A practical tool for selecting microalgal species for biodiesel production featured Journal of Renewable and Sustainable Energy 12, 063101 (2020); https://doi.org/10.1063/5.0010668

L. A. Martín, C. A. Popovich, M. C. Damiani, and P. I. Leonardi https://www.canr.msu.edu/uploads/files/biodiesel_production.pdf

https://afdc.energy.gov/fuels/biodiesel_production.html#:~:text=Biodiesel%20is%20produced%2 0from%20vegetable,and%20glycerin%20(a%20coproduct).

https://www.oecd.org/newsroom/makingthemostoutofbiofuels.htm

Environmental, economic, and energetic costs and benefits of biodiesel and ethanol biofuels Jason Hill, Erik Nelson, David Tilman, Stephen Polasky, and Douglas Tiffany

https://www.britannica.com/explore/savingearth/biofuel https://smartalternativefuels.com/ https://www.targray.com/biofuels/advantages#:~ https://www.amspecgroup.com/types-of-biofuel/ https://www.britannica.com/technology/biofuel