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Biofuels: Fuel of the Future

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Review Article

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ABSTRACT

Biofuels are fuels produced from biomass (plant or animal materials). Although biofuels exist in solid, liquid and gaseous form, but it usually refers to the liquid biofuels designed for usage as fuel for vehicles. It can be derived from agricultural crops, food crops (sugarcane and palms) or special energy crops, forestry, agricultural or even from fishery products and organic wastes in much less time.

INTRODUCTION

Biofuels are fuels that are derived from living organisms or organic material such as plants, molasses, animal fat, oils, used cooking grease, and even algae [1]. These are liquid fuels that are renewable; they can easily be reused and replaced in a short amount of time [2]. Renewable energy sources need not always be “green”; the biofuels are renewable energy but they are not always green i.e. environmental-friendly [3]. We humans have been using fossil fuels from ancient times, when coal was used for various purposes. Eventually the reserves of fossil fuels are going to be exhausted and we would have to move towards an alternative. That alternative is biofuels [4]. Biofuels were considered for use as back as 1970s. Till the 2000s, biofuels saw a rise in their usage which was supported by various policies introduced to facilitate their use, in various countries such as Brazil, USA, and in Europe [5]. However, during the world food price, the use of biofuels decreased and the policies supporting them were withdrawn as well. But due to their potential and deficiency of evidence, proving their impact on food prices, and an urge to solve the environmental crisis, they are bound to see an upsurge in their use in the coming decades For instance, Europe has decided that by 2020, 10% of the total energy or transportation fuel should come from biofuels [6,7].

Methods of biofuel production

The process of biofuel production involves breaking down the biomass and then refining that material into biofuels [8].

The following are some methods widely used for biofuel production:

Biochemical refining

It is a process whereby enzymes are used to break down the raw biomass to simpler sugars. Afterwards the action of microbes converts these sugars into biofuel [9]. The process of fermentation is utilized here. This method is most usually applied for ethanol production and is very similar to how beer is made [10]. As more research is being conducted it will be possible to produce biofuels using the structural components of the plant cells like cellulose instead of using sugars [11].

Thermochemical refining

This method utilizes heat for biofuel generation. In this method extreme heat is applied to biomass which causes its break

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down. Heat causes the liberation of oxygen from biomass material and the biomass is converted in a "biocrude" oil which is then refined to produce biofuel [12].

Gasification

Another method for producing biofuels is by making gas out of biomass, through a process known as thermochemical gasification or simply gasification. Extreme heat is applied, same as in thermochemical refining under anaerobic conditions. This causes the biomass to be converted to a gas known as "synthesis gas". This gas, through various chemical processes, is then converted into biofuels of different kinds [13,14].

Transesterification

Biodiesel is made usually by the method of transesterification. It is done by mixing an alcohol, usually methanol, with oil, such as vegetable oil like rapeseed oil or usually soybean oil, or fat like animal fat. The alcohol breaks down the triglycerides into esters; methyl and ethyl esters which are the biodiesels [15,16].

Biofuels can be divided into Primary and Secondary fuels based on processing [17]. Primary biofuels, are used in an unrefined form [18]. Whereas secondary biofuels are made by using plant or animal materials, include liquid biofuels [19].

Generations of biofuels

Based on the feedstock biofuels are divided into three generations. Feedstock is the raw material from which biofuels are made; it can be either plants, or leftovers from agriculture, animal fat, cooking grease, etc. The feedstock is now referred to as "Biomass" [20].

First generation biofuels

First generation biofuels are crop based fuels; they use plants as biomass [21]. Various plants are used, most commonly soybean, sunflower, sugar cane, cereals, cassava, etc. These rely on the sugars and starches stored in the plants for fuel generation These have been in use for a long time now [22]. Because they use plants instead of waste or leftovers, they raise serious environmental and ethical concerns, as the conflict with food interests and land used for agriculture [23]. In case of ethanol, the raw material includes corn, sugar cane, maize, etc., and for biodiesel soybean and canola is used [24,25].

Second generation biofuels

Second generation biofuels are "advanced biofuels", utilize non-traditional feedstock such as plant jatropha, or the waste and leftovers from agriculture or other plants [26]. These utilize the cellulose or lignocellulose, the structural molecules in the plant cells, for biofuel production [27]. They are less of a concern in comparison with the first-generation biofuels; but even still conflicts still occur as some plants that are used for cosmetics and non-agricultural purposes are utilized to make biofuels [28]. The second-generation biofuels are still being researched on and are yet to be produced on a large-scale basis [29].

Third generation biofuels

Algae based biofuels are third-generation biofuels. One clear advantage of using algae to produce biofuels is that the source i.e. algae is entirely apart from the crop or non-agricultural feedstock, which was a concern for the other generations of biofuels [30]. Algae also yields higher output of biofuel while requiring less input, also a clear benefit of using algae for biofuel production. Oil content in algae is much greater than plants that are generally used as feedstock [31].

Fourth generation biofuels

It produces sustainable energy but also a way of capturing and storing carbon dioxide. They can be made anywhere where carbon dioxide and water is found in sufficient concentration [32-34].

Types of biofuels

Bioethanol

Bioethanol is one of the most important renewable fuels because of the economic and environmental benefits [35]. The use of bioethanol as an alternative motor fuel has been increasing around the world. The expected environmental damages like global warming, acid rain and urban smog are the major concerns have convinced us to reduce the carbon emissions and move toward utilizing a variety of renewable energy resources such as solar, wind, biofuel, etc. that are less environmentally harmful in a sustainable way [36]. Ethanol is one of the efficient alternative biofuel. The combustion of ethanol is cleaner (because it contains oxygen) and thus it recognize as a potential biofuel alternative to gasoline [37]. it is prepared from sugars in grains such as corn, gasoline is then mixed with ethanol and sold commercially. Almost all gasoline sold in US has 10% ethanol in it, and is called E10 [38].

Biobutanol

Biobutanol is produced from starch fermentation and is a by-product of ABE fermentation process carried by Clostridium acetobutylicum [39-41]. it can be mixed with fossil fuels or can be consumed directly in car [42].

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Biomethanol

At present it is made from natural gas, but is also produced by gasification of biomass [43]. It involves vaporizing raw material at elevated temperatures to remove impurities and then passing it through a catalyst which converts it into methanol [44].

Biodiesel

It is produced by the Tran's desertification of the fatty acids found in vegetable oils such as rapeseed, sunflower and palm oil [15,45,46]. Conversion of vegetable oil by the fast food chain McDonald's into biodiesel is an example of its use [47].

Biogas

Anaerobic digestion or gasification of biomass by processes such as pyrolysis produces biogas [48,49]. Addition of energy crops and organic waste produces much higher yields [50].

Bio-hydrogen

Bio hydrogen can be produced by means of pyrolysis, gasification or biological fermentation either dark fermentation or photofermentaion using bacteria [51-53]. While photofermentaion occurs in the presence of light [54]. But, both processes have low productivities [55].

Reformulated gasoline components

Most reformulated gasoline components are fuel additives meant for reduction of pollution, such as methyl tertiary butyl ether (MTBE) and ethyl tertiary butyl ether (ETBE) [56,57].

Advantages of biofuels

Cost

Biofuels have been significantly cheaper in cost than gasoline and other fossil fuels. In fact, ethanol is already less expensive than diesel and gasoline [58].

Source material

Biofuels can be generated from a wide range of materials including crop waste, manure, and other byproducts [59].

Renewability

Biofuels are easily renewable as new crops are grown and waste material is collected [60].

Job opportunities

Biofuel manufacturing plants can employ numerous workers, creating new jobs in rural areas [19].

Lower level of carbon release

Combustion of biofuels produces ominously less carbon, hence less damage to atmosphere and lower air pollution [61].

Easy to extract

We all know that gasoline extracted from ground which are the fossils fuels. Fossils fuels will be end in near future. But in case of biofuels it is quite easy for extraction and can be purified easily [62].

Reduce foreign fuels demands

Most of the countries lack fossils fuels so they were compelled to asked for fossils fuels from other countries. Prices of fuels are much higher as a result it effects much to their economic values. Alternative energy resources reduce the dependency on foreign demands about fossils fuels [1,63].

Disadvantages of biofuels

Energy output

Biofuels yields low energy output. Therefore need greater quantities to be consumed in order to produce the same energy level [64]. There is no use of converting biofuels into ethanol rather than electricity [65].

Carbon emissions

Though biofuels do not add carbon to the atmosphere but the production process including cultivation machinery release increased amount of carbon [66].

High cost

Biofuel refining requires high investment which makes the production expensive [67].

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Food shortages

Utilizing cropland to grow fuel crops could possibly lead to food shortages [68]. Biofuels are extracted from crops which contains large amount of sugar. Moreover, most of them used as foods. The wastes of animals are best nutrients for soil but if we use wastes and most of the crops for biofuels it may cause the shortage and may one of the root of inflation about foods. This all consequences put pressure on growth of crops [69].

Water use

Considerable amounts of water are required for cultivation of biofuel crops which could stress water resources and also cause more water pollution [70].

Crop rotation

Due to demands of same crops farmers are producing same crops every year. This seems attractive to the economics but growing same crops reduces the nutrients of soils. Farmers attentions moved toward monoculture which diminish the variations [71].

Environmental effects

As mention earlier that crop rotations done which cause reduction in nutrients of soil, so farmers used different fertilizers. Fertilizers contains nitrogen and phosphorous. These all washed away from soils and pollutant the environments [72].

Biofuels on the market

Presently, ethanol and biodiesel are the most commercially used biofuels produced from starch [73]. Worldwide production of biofuel reached 105 billion liters in 2010, an increase by 17% from the previous year [74]. In 2010 the total amount of ethanol produced was 86 billion liters, 90% of which was produced by Brazil and United States [75]. Global biofuels production rose by 2.6% in 2016, below the 10-year average of 14.1%, but faster than in 2015 (0.4%) [74].

Feedstock for biofuels

Corn

The greater part of the ethanol delivered at worldwide level originates from corn as a rule and U.S. corn trims particularly [74]. By 2012, more than 40% of the corn crops delivered in the U.S were utilized for making ethanol [75]. Since ethanol is likewise the liquor found in drinks, it's critical to note not all that ethanol was utilized for fuel. In 2013, of the 36 billion gallons of biofuels delivered in the U.S, somewhere in the range of 15 billion of those powers contained grain-based ethanol (which likewise incorporates corn) [74].

Pros

- Corn has been collected for quite a while, and there's a strong framework officially dynamic for planting it, reaping the products, and afterward preparing them [76].
- Indirect arrive utilize costs don't make a difference, with regards to corn [77].
- The procedure of transforming corn starches into ethanol is generally uncomplicated [78].
- Ethanol can be created from the unusable parts of the corn, as well the stalk, cob etc [76].
- Corn-based biofuels can supplant around 25% of the gas devoured in the U.S [79].

Cons

- Compared to other, more effective feedstock trims, the biofuel yield of corn is a minor 350 gallons/section of land all things considered [80].
- It's costly to prepare corn and ensure it against bugs, contrasted with different products. Likewise, this builds the danger of tainting the dirt and water in the region where the harvest is developed [81].
- Using corn crops for fuel has supported sustenance costs and expanded the rate of world yearning [82].
- Corn ethanol has a scarcely positive vitality yield of around 1.2 [83].

Sugar cane

Up to this point, sugar stick was the world's fundamental wellspring of ethanol, due to its predominance in Brazil [84]. Brazil was the world's best liquor fuel maker, before the United States picked up matchless quality in the field [85]. Amid the 1970s, Brazil was the objective of an oil ban, which made the nation's pioneers swing to sugar stick based ethanol to supply its fuel needs. Right now, Brazilian autos keep running on no less than 22% ethanol-mixed gas, yet the populace can likewise purchase 100% unadulterated ethanol [86]. Every year, Brazil creates a normal of 5 billion gallons (18 billion liters) of ethanol [87].

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Pros

- As is the situation with corn, the foundation for reaping sugarcane (and in addition for planting and preparing) has just been set up [88].
- Plantation sizes or sugarcane don't change since there are typically no land utilize costs set up for sugarcane [89].
- Sugarcane crops yield a higher measure of fuel (650 gallons/section of land) [90].
- In the instance of products with no land utilize costs set up, the level of CO_2 emanations for sugarcane-based ethanol is up to 90% lower than that of fuel [91].

Cons

- The net vitality yield of sugarcane is generally low (despite the fact that it's higher than that of corn) [92].
- Sugarcane can't be as broadly developed as other feedstock crops since it requires certain atmosphere conditions [93].
- In numerous Southern and Central American nations, sugarcane is a staple nourishment; utilizing it for fuel would exhaust those sustenance assets [94].
- All things considered, sugarcane is additionally not a versatile harvest for biofuel. While developing it for this design is appropriate in Brazil and a few different nations, it can't be utilized to give vitality to the whole world [95].

Soybeans

While corn and sugarcane are specific harvests to a modest bunch of areas, soybeans are generally developed for nourishment in Asia, South American, and North America [96]. The U.S. represents 32% of worldwide soybean generation and the world's second biggest maker is Brazil (28%) [97].

Pros

- Soybeans can be developed in many places far and wide [98].
- Crops are low-support, regarding preparation and different needs [99].

Cons

- Soybean crops have the most reduced yield among all feedstock crops for biomass: close to 70 gallons/section of land (very nearly 10 times lower than some second era biofuel crops) [100].
- The net vitality yield of soybean crops is negative (i.e. they require more vitality to develop than the vitality they create) [101].
- Soy is a noteworthy sustenance source in every one of the areas where it's right now being developed [16].
- While it's not hard to keep up, soy as a product is somewhat inclined to pervasions and infections [102].
- Toward the day's end, soybeans are conceivably the poorest contrasting option to delivering natural mass for biofuels [103].

Vegetable oil

Strangely enough, contingent upon the procedure through which it is inferred, vegetable oil can be classed both as a first and as a moment age biofuel. At the point when it's 'virgin' oil, i.e. created straightforwardly from vegetables, it falls under the original classification; when it's utilized cooking oil, it's a moment age fuel [104].

Pros

- It's anything but difficult to change over to fuel [105].
- Since it can be gotten from an extensive variety of vegetables, it's accessible all through the world [106].
- In most cases, it can be utilized straightforwardly in diesel motors, without waiting be changed excessively [107].

Cons

Vegetable oils are real sustenance staples far and wide [108].

- In a few cases, it needs to be changed, since utilizing it as is can cause carbon. This, thusly, can harm diesel motors [109].
- The deforestation of old development woodlands, keeping in mind the end goal to supplant them with palm trees developed for oil, has caused enormous biodiversity issues and furthermore expanded carbon outflow levels [110].

All through time, a few other nourishment crops have been utilized as feedstock for biofuel. These incorporate wheat, sugar beet, peanuts, rapeseed, and numerous others [111]. Be that as it may, they all faltered onto a similar issue: they're all significant sustenance yields and utilizing them for fuel debilitated the evolved way of life.

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The impact of biofuels

Biofuels, though as beneficial they are, are still a concern for researchers, the policy makers, and the end users. The debate is whether they are any better than the fossil fuels or not [112]. As is believed that biofuels are less of a threat to environment as they have lower greenhouse gas emissions, it is still unclear. Also, it is a myth that they are much cheaper than the traditional fossil fuels; in fact, they are not [113].

Some of the impacts that biofuels pose are as follows:

Impacts on food and its prices

Biofuels are believed to impact foods by increasing their prices [114]. This is done by either of two ways; by using the food crops for biofuel production or by directing a land use change for producing non-agricultural feedstock to generate biofuels [99,115]. However, the studies conducted to analyze the correlation between increase in food prices and biofuels production as trustworthy or reliable as they were not published in peer-reviewed journals but rather as technical reports and no such research proved a relation in between the two during a price hike in 2011 [116].

Impacts on cultivation land

A problem that arises from biofuels is the land displacement for biofuel production [117]. This can happen in two ways; either the land is displaced from crops non-feedstock crops such as rice to crops used as feed stocks or diverting forest land for biofuel production [118-120]. Several studies have been conducted to analyze this issue, but none have been able to correctly scrutinize the impact of biofuels on land supply; as they are either biased or don't consider the different constraints or variables as necessary in assessing the effect.

Impact on biodiversity

Biofuel production affects ecological biodiversity by using land for production of feedstock [121]. Since most of the feedstock crops require tropical climate, their cultivation can lead to other areas such as rainforests to be converted into tropical areas [122]. An example is Malaysia; the palm oil cultivation for feedstock has replaced the natural forests and diversity [123]. Similar has happened in Indonesia. Even the crops cultivated for feedstock are now being listed as invasive species by certain countries such as South Africa which now considers jatropha as one [124,125].

Impact on greenhouse gas emissions

It is thought about biofuels that they have lower greenhouse gas emissions [126]. That is only true if we exclude the greenhouse gas emissions from the destruction of land for feedstock production [127]. For instance, the OECD has given an approximate that sugarcane ethanol cuts greenhouse gas emissions by 90% than gasoline IEA also theorizes that cellulosic feedstock can cut GHG emissions by 70%-90% [128-130].

CONCLUSION

With the passage of time bio-based fuels are taking over the market because of their environmental friendly nature and inexpensive production. Since biofuels are produced from the plant-derived polysaccharides, CO_2 does not increase when biofuels are used (combusted), which refers to the concept of carbon neutrality. Biofuels can be boon for us if proper research is conducted to analyze and identify the issues and concerns related to them; and then decimate those issues. We can't rely on the fossil fuels as they are going to be depleted eventually, and they pose a serious concern to our environment as well. Eventually we would need renewable energy sources like biofuels.

REFERENCES

1. International Panel for Sustainable Resource Management. UNEP. 2009.
2. Ragauskas AJ, et al. The path forward for biofuels and biomaterials. Science. 2006;311:484-489.
3. Scharlemann JPW, et al. How green are biofuels? Science. 2008;319:43-44.
4. Bhattarai K, et al. Biofuel: an alternative to fossil fuel for alleviating world energy and economic crises. J Environ Sci Health A Tox Hazard Subst Environ Eng. 2011;46:1424-1442.
5. Specht Z, et al. Biofuels History and Review. 2011:1-33.
6. Guo M, et al. Bioenergy and biofuels: History, status, and perspective. Renew Sustain Energy Rev. 2015;42:712-725.
7. Songstad DD, et al. Historical perspective of biofuels: Learning from the past to rediscover the future. Springer. 2011:1-7.
8. https://www.uspto.gov/patents-application-process/checking-application-status/search-application
9. Karaosmanoglu F, et al. Investigation of the refining step of biodiesel production. Energ Fuel. 1996;10:890-895.

e-ISSN:2347-7830
p-ISSN:2347-7822

10. Cherubini F, et al. The biorefinery concept: Using biomass instead of oil for producing energy and chemicals. Energ Convers Manage. 2010;51:1412-1421.
11. Weng JK, et al. Emerging strategies of lignin engineering and degradation for cellulosic biofuel production. Curr Opin Biotechnol. 2008;19:166-172.
12. Demirbas MF, et al. Biorefineries for biofuel upgrading: A critical review. Appl Energy. 2009;86:151-161.
13. Larson ED, et al. Biofuel production technologies: status and prospect. Princeton Environmental Institute Princeton University, Princeton, NJ USA. 2007:1-15.
14. Henstra AM, et al. Microbiology of synthesis gas fermentation for biofuel production. Curr Opin Biotechnol. 2007;18:200-206.
15. Fukuda H, et al. Biodiesel fuel production by transesterification of oils. J Biosci Bioeng. 2001;92:405-416.
16. Kim HJ, et al. Transesterification of vegetable oil to biodiesel using heterogeneous base catalyst. Catal Today. 2004;93:315-320.
17. Kojima M, et al. Potential for biofuels for transport in developing countries. ESMAP, USA. 2005:1-182.
18. Abila N, et al. Biofuels adoption in Nigeria: A preliminary review of feedstock and fuel production potentials. Management of Environmental Quality: An International Journal. 2010;21(6), 785-795.
19. Nigam PS, et al. Production of liquid biofuels from renewable resources. Prog Energy Combust Sci. 2011;37:52-68.
20. Naik SN, et al. Production of first and second generation biofuels: A comprehensive review. Renew Sust Energ Rev. 2010;14:578-597.
21. Naqvi M, et al. First-Generation Biofuels. John Wiley & Sons. 2015.
22. de Vries SC, et al. Resource use efficiency and environmental performance of nine major biofuel crops, processed by first-generation conversion techniques. Biomass Bioenergy. 2010;34:588-601.
23. Mohr A, et al. Lessons from first generation biofuels and implications for the sustainability appraisal of second generation biofuels. Energy Policy. 2013;63:114-122.
24. Gray KA, et al. Bioethanol. Curr Opin Chem Biol. 2006;10:141-146.
25. Maa F, et al. Biodiesel production: A review. Bioresour Technol. 1999;70:1-15.
26. Sims RE, et al. An overview of second generation biofuel technologies. Bioresour Technol. 2010;101:1570-1580.
27. Schenk PM, et al. Second generation biofuels: High-efficiency microalgae for biodiesel production. Bioenergy Res. 2008;1:20-43.
28. Antizar-Ladislao B, et al. Second-generation biofuels and local bioenergy systems. Biofuel Bioprod Bior. 2008;2:455-469.
29. Eisentraut A, et al. Sustainable Production of Second-Generation Biofuels. 2010:1-10.
30. Dragone G, et al. Third generation biofuels from microalgae. Current Res, Technol and Education Topics in Applied Microbiol and Microb Biotechnol. 2010;2:1355-1366.
31. Behera S, et al. Scope of algae as third generation biofuels. Front Bioeng Biotechnol. 2015;2:1-14.
32. Dutta K, et al. Evolution retrospective for alternative fuels: First to fourth generation. Renew Energ. 2014;69:114-122.
33. Aro EM, et al. From first generation biofuels to advanced solar biofuels. Ambio. 2016;45:24-31.
34. Demirbas A, et al. Competitive liquid biofuels from biomass. Appl Energy. 2011;88:17-28.
35. Goldemberg J, et al. Energy and sustainable development. Worlds Apart: Globalization and the Environment. 2003:53-65.
36. Balat M, et al. Recent trends in global production and utilization of bio-ethanol fuel. Appl Energy. 2009;86: 2273-2282.
37. Mielenz JR, et al. Ethanol production from biomass: Technology and commercialization status. Current Opinion in Microbial. 2001;4:324-329.
38. Durre P, et al. Biobutanol: An attractive biofuel. Biotechnol J. 2007;2:1525-1534.
39. Jones DT, et al. Acetone-butanol fermentation revisited. Microbiol Rev. 1986;50:484-524.
40. Rubin EM, et al. Genomics of cellulosic biofuels. Nature. 2008;454:841-845.
41. Kumar M, et al. Developments in biobutanol production: New insights. Appl Energy. 2011;881999-2012.
42. Demirbas A, et al. Biomethanol Production from Organic Waste Materials. Taylor & Francis Group. 2008;30:565-572.
43. Shamsul NS, et al. An overview on the production of bio-methanol as potential renewable energy. Renew Sust Energ Rev. 2014;33:578-588.

e-ISSN:2347-7830
p-ISSN:2347-7822

44. Marchetti JM, et al. Possible methods for biodiesel production. Renew Sust Energ Rev. 2007;11:1300-1311.

45. Knothe G, et al. Analyzing biodiesel: Standards and other methods. J Am Oil Chem Soc. 2006;83:823-833.

46. Dorado MP, et al. An alkali–catalyzed transesterification process for high free fatty acid waste oils. Trans ASAE. 2002;45:525-529.

47. Weiland P, et al. Biogas production: Current state and perspectives. Appl Microbiol Biotechnol. 2010;85:849-860.

48. Lastella GC, et al. Anaerobic digestion of semi-solid organic waste: biogas production and its purification. Energ Convers Manage. 2002;43:63-75.

49. Taherzadeh MJ, et al. Pretreatment of lignocellulosic wastes to improve ethanol and biogas production: a review. Int J Mol Sci. 2008;9:1621-1651.

50. Kapdan IK, et al. Bio-hydrogen production from waste materials. Enzyme Microb Technol. 2006;38:569-582.

51. Argun H, et al. Bio-hydrogen production by different operational modes of dark and photo-fermentation: An overview. Int J Hydrogen Energy. 2011;36:7443-7459.

52. Chong ML, et al. Biohydrogen production from biomass and industrial wastes by dark fermentation. Int J Hydrogen Energy. 2009;34:3277-3287.

53. Ozgur E, et al. Biohydrogen production from beet molasses by sequential dark and photofermentation. Int J Hydrogen Energy. 2010;35:511-517.

54. Manish S, et al. Comparison of biohydrogen production processes. Int J Hydrogen Energy. 2008;33:279-286.

55. Seddon D, et al. Reformulated gasoline, opportunities for new catalyst technology. Catalysis Today. 1992;15:1-21.

56. Steffan RJ, et al. Biodegradation of the gasoline oxygenates methyl tert-butyl ether, ethyl tert-butyl ether, and tert-amyl methyl ether by propane-oxidizing bacteria. Appl Environ Microbiol. 1997;63: 4216-4222.

57. Hill J, et al. Environmental, economic and energetic costs and benefits of biodiesel and ethanol biofuels. Proc Natl Acad Sci USA. 2006;103:11206-11210.

58. Demirbas A, et al. Biofuels sources, biofuel policy, biofuel economy and global biofuel projections. Energ Convers Manage. 2008;49:2106-2116.

59. Ewing M, et al. Biofuels production in developing countries: Assessing trade-offs in welfare and food security. Environ Sci Policy. 2009;12:520-528.

60. Tilman D, et al. Carbon-negative biofuels from low-input high-diversity grassland biomass. Science. 2006;314:1598-1600.

61. Pragya N, et al. A review on harvesting, oil extraction and biofuels production technologies from microalgae. Renew Sust Energ Rev. 2013;24:159-171.

62. Lamers P, et al. International bioenergy trade: A review of past developments in the liquid biofuel market. Renew Sust Energ Rev. 2011;15:2655-2676.

63. McKone TE, et al. Grand challenges for life-cycle assessment of biofuels. Environ Sci Technol. 2011;45:1751-1756.

64. DeCicco JM, et al. Biofuels and carbon management. Clim Change. 2012;111:627-640.

65. Pandey A, et al. Biofuels: Alternative feedstocks and conversion processes. Elsevier USA. 2011:1-642.

66. Pimentel D, et al. Food versus biofuels: Environmental and economic costs. Hum Ecol. 2009;37:1-12.

67. Mathews JA, et al. Biofuels and indirect land use change effects: The debate continues. Biofuel Bioprod Bior. 2009;3:305-317.

68. Rosenthal E, et al. Rush to use crops as fuel raises food prices and hunger fears. The New York Times. 2011.

69. Kiniry JR, et al. Biofuels and water use: Comparison of maize and switchgrass and general perspectives. New research on biofuels, Nova Science, New York. 2008:17-30.

70. Kaltschmitt M, et al. Life cycle analysis of biofuels under different environmental aspects. Biomass Bioenergy. 1997;12:121-134.

71. Zah R, et al. Life cycle assessment of energy products: Environmental assessment of biofuels. 2007:1-19.

72. De Wilde HPJ, et al. Market analysis biofuels. ECN. 2009:1-49.

73. Searchinger T, et al. Use of US croplands for biofuels increases greenhouse gases through emissions from land-use change. Science. 2008;319:1238-1240.

74. Tyndall JC, et al. Corn stover as a biofuel feedstock in Iowa's bio-economy: An Iowa farmer survey. Biomass Bioenergy. 2011;35:1485-1495.

e-ISSN:2347-7830
p-ISSN:2347-7822

75. Alonso DM, et al. Production of biofuels from cellulose and corn stover using alkylphenol solvents. ChemSusChem. 2011;4:1078-1081.

76. Landis DA, et al. Increasing corn for biofuel production reduces biocontrol services in agricultural landscapes. Proc Natl Acad Sci USA. 2008;105:20552-20557.

77. Pimentel D, et al. Ethanol production using corn, switchgrass, and wood: Biodiesel production using soybean and sunflower. Nat Resour Res. 2005;14:65-76.

78. Graham RL, et al. Current and potential US corn stover supplies. Agron J. 2007;99:1-11.

79. Petrou EC, et al. Biofuels: A survey on pros and cons. Energ Fuel. 2009;23:1055-1066.

80. Field CB, et al. Biomass energy: the scale of the potential resource. Trends Ecol Evol. 2008;23:65-72.

81. Singh A, et al. Key issues in life cycle assessment of ethanol production from lignocellulosic biomass: Challenges and perspectives. Bioresour Technol. 2010;101:5003-5012.

82. Lin Y, et al. Ethanol fermentation from biomass resources: Current state and prospects. Appl Microbiol Biotechnol. 2006;69:627-642.

83. Martinelli LA, et al. Expansion of sugarcane ethanol production in Brazil: environmental and social challenges. Ecol Appl. 2008;18:885-898.

84. Marris E, et al. Sugar cane and ethanol: Drink the best and drive the rest. Nature. 2006;444:670-672.

85. Heinimo J, et al. Production and trading of biomass for energy: An overview of the global status. Biomass Bioenerg. 200933:1310-1320.

86. Goldemberg J, et al. The Brazilian biofuels industry. Biotechnol Biofuels. 2008;1:1-6.

87. Wang M, et al. Well-to-wheels energy use and greenhouse gas emissions of ethanol from corn, sugarcane and cellulosic biomass for US use. Environ Res Lett. 2012:7:1-14.

88. Boddey RM, et al. Biological nitrogen fixation in sugar cane: a key to energetically viable biofuel production. Crit Rev Plant Sci. 1995;14:263-279.

89. Gary BR, et al. Biomass Energy Data Book: Edition 4. Oak Ridge National Lab, Oak Ridge, TN, USA. 2011.

90. Macedo IC, et al. Greenhouse gases emissions in the production and use of ethanol from sugarcane in Brazil: the 2005/2006 averages and a prediction for 2020. Biomass Bioenerg. 2008;32:582-595.

91. Quintero JA, et al. Fuel ethanol production from sugarcane and corn: comparative analysis for a Colombian case. Energy. 2008;33:385-399.

92. Kim M, et al. Composition of sugar cane, energy cane, and sweet sorghum suitable for ethanol production at Louisiana sugar mills. J Ind Microbiol Biotechnol. 2011;38:803-807.

93. Weber C, et al. Trends and challenges in the microbial production of lignocellulosic bioalcohol fuels. Appl Microbiol Biotechnol. 2010;87:1303-1315.

94. Rabelo SC, et al. Production of bioethanol, methane and heat from sugarcane bagasse in a biorefinery concept. Bioresour Technol. 2011;102:7887-7895.

95. Gibbs HK, et al. Carbon payback times for crop-based biofuel expansion in the tropics: the effects of changing yield and technology. Environ Res Lett. 2008:3:1-11.

96. Fargione J, et al. Land clearing and the biofuel carbon debt. Science. 2008;319:1235-1238.

97. Karmakar A, et al. Properties of various plants and animals feedstocks for biodiesel production. Bioresour Technol. 2010;101:7201-7210.

98. Cavalett O, et al. Integrated environmental assessment of biodiesel production from soybean in Brazil. J Clean Prod. 2010;18:55-70.

99. Ranalli P, et al. Improvement of Crop Plants for Industrial End Uses. Springer. 2007:1-533.

100. Goldsmith PD, et al. Economics of soybean production, marketing, and utilization. Elsevier. 2008;117-150.

101. Perlack RD, et al. Biomass as feedstock for a bioenergy and bioproducts industry: the technical feasibility of a billion-ton annual supply. Oak Ridge National Lab Tennessee. 2005.

102. Palti J, et al. Cultural Practices and Infectious Crop Diseases. Springer. 2012;9:73-189.

103. Maltitz GV, et al. Options for suitable biofuel farming: Experience from Southern Africa. Unu-Wider. 2017:1-38.

104. Zhang Y, et al. Biodiesel production from waste cooking oil: 1. Process design and technological assessment. Bioresour Technol. 2003;89:1-16.

e-ISSN:2347-7830
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105. Demirbaş A, et al. Biodiesel fuels from vegetable oils via catalytic and non-catalytic supercritical alcohol transesterifications and other methods: A survey. Energ Convers Manage. 2003;44:2093-2109.

106. Subramanian KA, et al. Utilization of liquid biofuels in automotive diesel engines: An Indian perspective. Biomass Bioenergy. 2005;29:65-72.

107. Usta N, et al. Combustion of biodiesel fuel produced from hazelnut soapstock/waste sunflower oil mixture in a diesel engine. Energ Convers Manage. 2005;46:741-755.

108. Mittelbach M, et al. Diesel fuel derived from vegetable oils, VI: Specifications and quality control of biodiesel. Bioresour Technol. 1996;56:7-11.

109. Bajpai D, et al. Biodiesel: Source, production, composition, properties and its benefits. J Oleo Sci. 2010;55:487-502.

110. Rutz D, et al. Biofuel technology handbook. WIP Renewable Energies. 2007:1-149.

111. Birur D, et al. Impact of biofuel production on world agricultural markets: A computable general equilibrium analysis. GTAP working paper. 2008.

112. Mueller SA, et al. Impact of biofuel production and other supply and demand factors on food price increases in 2008. Biomass Bioenergy. 2011;35:1623-1632.

113. Ajanovic A, et al. Biofuels versus food production: does biofuels production increase food prices? Energy. 2011;36:2070-2076.

114. Mitchell D, et al. A Note on Rising Food Prices. 2008.

115. Zilberman D, et al. The impact of biofuels on commodity food prices: Assessment of findings. Am J Agric Econ. 2012;95:275-281.

116. Baier SL, et al. Biofuels Impact on Crop and Food Prices: Using an Interactive Spreadsheet. 2009.

117. Sorda G, et al. An overview of biofuel policies across the world. Energ Policy. 2010;38:6977-6988.

118. Rathmann R, et al. Land use competition for production of food and liquid biofuels: An analysis of the arguments in the current debate. Renew Energ. 2010;35:14-22.

119. Hellmann F, et al. Impact assessment of the European biofuel directive on land use and biodiversity. J Environ Manage. 2010;91:1389-1396.

120. Davis SC, et al. Impact of second-generation biofuel agriculture on greenhouse-gas emissions in the corn-growing regions of the US. Front Ecol Environ. 2012;10:69-74.

121. Danielsen F, et al. Biofuel plantations on forested lands: double jeopardy for biodiversity and climate. Conserv Biol. 2009;23:348-358.

122. Koh LP, et al. Biofuels, biodiversity, and people: understanding the conflicts and finding opportunities. Biol Conserv. 2008;141:2450-2460.

123. Obidzinski K, et al. Environmental and social impacts of oil palm plantations and their implications for biofuel production in Indonesia. Ecol Soc. 2012;17:1-25.

124. Joly CA, et al. Biofuel impacts on biodiversity and ecosystem services. Bioenergy & Sustainability. 2015:1-27.

125. Timilsina GR, et al. How much hope should we have for biofuels?. Energy. 2011;36:2055-2069.

126. Cherubini F, et al. Energy-and greenhouse gas-based LCA of biofuel and bioenergy systems: Key issues, ranges and recommendations. Resour Conserv Recy. 2009;53:434-447.

127. Kendall A, et al. Accounting for time-dependent effects in biofuel life cycle greenhouse gas emissions calculations. Environ Sci Technol. 2009;43:7142-7147.

128. Melillo JM, et al. Indirect emissions from biofuels: how important?. Science, 2009;326:1397-1399.

129. Schneider UA, et al. Economic potential of biomass based fuels for greenhouse gas emission mitigation. Environ Resour Econ. 2003;24:291-312.

130. Hill J, et al. Climate change and health costs of air emissions from biofuels and gasoline. Proc Natl Acad Sci USA. 2009;106:2077-2082.