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Biofuel for Modern Farming

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ABSTRACT

Agriculture remains one of the most energy-intensive sectors, so the adoption of green energy technologies offers a sustainable pathway to transform modern farming. Roughly, 180–240 million tonnes of crop residues remain after their conventional applications, yearly, in India's agrarian system. An intimidating 92 million tonnes are combusted in the open every year, which causes adverse effects, including the emission of greenhouse gases that contribute to global warming, increased levels of smog that beget health hazards, loss of biodiversity of agricultural lands, and the deterioration of soil fertility. Bioethanol, compressed biogas, biodiesel, and advanced biofuels can be made from remnants such as paddy straw, wheat stubble, maize stalks, and sugarcane bagasse through the application of highly advanced technologies such as enzymatic hydrolysis, anaerobic digestion, and production of cellulosic ethanol. Biofuels derived from crop remains – similar to biogas, bioethanol, and biodiesel – not only provide renewable energy but also produce fresh income aqueducts for farmers, reduce dependence on fossil fuels, and support a circular economy in agriculture. This poster emphasizes the prospects for residue-grounded biofuels as a green technology movement in contemporary agriculture, looking into the metamorphosis of what had been deemed as waste material into a source of renewable energy. Emphasizing key results, identifying new trends, and proposing directions for future research to grease crop residue retention to be embraced and maximized to make sustainable and eco-friendly agricultural practices in today's agricultural ecosystem.

Key words: Agricultural waste, Crop residues, Policy challenges, Renewable energy, Sustainable agriculture

INTRODUCTION

According to research, it is suggested that coal reserves could last over 100 years, while oil and natural gas may last several years, which concludes on a note that fossil fuels are depleting at an exponential rate.[1] Although it is known that fossil fuels are replenished year after year, they are still considered non-renewable resources, as the rate at which it is replenished is much slower than that of their depletion. Combustion of fossil fuels generates around 21.3 billion tonnes of carbon dioxide along with other greenhouse gases per year, and only 50% of it is used up by nature. Still, there are an overall 10.65 billion tonnes of CO_2 per annum into the environment.[2] Thus, the threat still exists. Hence, alternative renewable and sustainable sources of energy should be introduced to continue our pace of living. Biofuels are considered to be environmentally safe, renewable sources and alternative fuels that can be utilized in numerous ways. At present, a growing interest is observed in the use of agricultural products for biofuel production, as they give minor emissions and are sustainable as compared to traditional diesel fuel. Biofuel can be used for blending with gasoline as a fuel extender and octane-enhancing agent or used as a neat fuel in internal combustion engines.[3] Biofuels have

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been in use globally for years to increase energy self-sufficiency, reduce vehicular emissions, and increase transport sustainability. Biofuels can be categorized into four types, based on the feedstock: 1st, 2nd, 3rd, and 4th generation. In this very paper, we shall focus mainly on the 2nd generation that is produced from lignocellulosic plant biomass, which can be an impending feedstock for biofuel generation and has an abundant availability worldwide.[4] Lignocellulose consists of lignin, cellulose, and hemicellulose as main components in a complex structure, which is unique for the mitigation of degradation.

India is an agrarian nation with about 140 million hectares of net sown area, with a large diversity in type and productivity of crops. A huge quantity of crop residues is also generated as a by-product of crop production.[5] These crop residues are tremendously beneficial to farmers. These can be used as animal feed, soil mulch and manure, fuel, and thatching. However, a large portion of these residues is burnt on-farm. However, these crop residues can be utilized for the production of power. Various kinds of crop residue are being produced around the world that can be transformed into biofuels using different treatment and production methods, such as thermochemical conversion (such as combustion, pyrolysis, hydrothermal liquefaction, and gasification), biochemical conversion (e.g., microbial fermentation, enzymatic hydrolysis, and anaerobic digestion), and chemical treatment (e.g., transesterification).[6]

METHODOLOGY

Approaches for Biofuel Production from Agro-Based Biomass

Biofuel production from lignocellulosic materials, being carbon compounds, can have innumerable pathways, but some common characteristics in all of them are:

1. Depolymerization of cellulose and hemicellulose to soluble sugar units
2. Effective fermentation of sugars
3. Integration of advanced methods to minimize energy requirements for processing
4. Cost-effective technologies.

Pre-treatment of biomass

Because of the complex packing of the constituents- cellulose, hemicellulose, lignin of lignocellulosic materials, a challenge of low microbe and enzymatic availability of cellulose is faced. To overcome this and upsurge the enzyme accessibility, the pre-treatment step is very crucial.[7] It breaks down the complex structure of lignin and facilitates enzymatic hydrolysis that opens up the availability of polysaccharides for transformation to monosaccharides. The pre-treatment process consists of physical, chemical, and biological processes. According to successful studies, the correct choice of pre-treatment of lignocellulosic biomass (LCB) significantly influences the biofuel yield.

Physical pre-treatment

These include the usage of mechanical forces, pressure, or temperature to change LCB structurally: reduce particle size (roughly 0.2–2 mm after milling), degree of polymerization, and crystallinity to enhance enzymatic digestion of lignocellulose, and increase specific surface area.[8]

Chemical pre-treatment

Breaking down lignin and hemicellulose in biomass is important to make it easier to hydrolyse. Chemical pre-treatment is usually the way to go. These components are broken down into smaller sugar particles using mostly acid and base for further fermentation. One way to do this is with acid pre-treatment, which can be done with a variety of acids. Sulfuric, hydrochloric, phosphoric, and nitric acids are all options.[9] Using acids to break down plant material can be quite effective. They quickly dissolve the bonds between polysaccharides and lignin. Change the structure of cellulose.

Biological pre-treatment

Biological pre-treatment methods using microbes like bacteria and fungi are becoming more popular for breaking down lignocellulose. These methods are eco-friendly and cost-effective. However, it takes careful testing and research to pick an efficient microorganism or a combination of microbes that can produce the necessary enzymes for lignocellulose breakdown.[5]

Enzymatic hydrolysis of LCB

This process includes the breakdown of tough, complex, crystalline, and amorphous structures of biomass into simpler soluble sugars, mainly glucose and xylose, by enzymes, which are then processed for the production of biofuels.[2]

Anaerobic digestion

Anaerobic digestion is a process that breaks down matter using microorganisms, without oxygen. This method is really useful for getting rid of all sorts of waste from places like farms, factories, and even homes.[4]

Fermentation

Fermentation is a process that uses microorganisms or their enzymes to make acids and alcohol. There is a type of fermentation, known as solid-state fermentation, where materials with any free water are used to help microorganisms grow.[8]

RESULTS AND DISCUSSION

- Agricultural LCB can act as a promising feedstock for biofuel production with proper these pre-treatment methods have been practiced to increase lignocellulose hydrolysis and degradation. The pre-treatment process is a crucial step that directly affects the hydrolysis of lignocellulose to soluble sugars that are further used for fermentation or anaerobic digestion for biofuel production.[8,10]
- Downstream processes are also important, along with other pathways in biofuel production, such as anaerobic digestion and fermentation. They separate unwanted compounds from a blend of production yield. It is highly recommended to put downstream processes into effect for the recovery of the product and finishing, without which the entire production process is incomplete.[3,11]

CONCLUSION

The main objective of the mentioned techniques for biofuel production is to cut costs, maximize yield, and better conservation. The pre-treatment process is an important step that has a direct impact on the further process. The downstream process is very significant as it separates the unwanted substance from the biofuel and can be utilized fully. A good biofuel production method should emphasize high yield, being inexpensive, and being environmentally sustainable.

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