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Achieving sustainable development goals through whey-based greener fuels

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Abstract

The zeal to make the earth a liveable planet for current and future generations has forced nations across the globe to achieve sustainable development goals. Promoting the use of biofuels is one such effort that promises to assist in meeting the developmental goals due to their cleaner and greener credentials. Whey being a potential source of biofuels has changed its perception from that of a waste material to that of a renewable source of such fuels.

Introduction

Fossil fuels were a one-of-a-kind exploration that revolutionised modern living. They have sustained themselves as irreplaceable energy sources, as even today they serve as primary energy sources by aiding in the production of 75% of the heat and energy as well as meeting 20% of the fuel demands. Modern civilization's dependence on fossil fuels has contributed to enormous economic progress, but this has come at a heavy price in terms of deteriorating environmental health. Fossil fuels' reckless and imprudent use has led to detrimental environmental consequences like climate change and global warming. The burning of fossil fuels is one of the major contributors to greenhouse gases, which further aggravate the problem of global warming and the ensuing climate change. Climate change is of immense concern to mankind as it threatens the survival of both humans and animals alike.

Need for sustainable development

The use of fossil fuels is faced with a few bottlenecks. Fossil fuels are generally non-renewable and are unevenly distributed across the globe. Going by the current trends of consumption, these fuels will get exhausted sooner or later, as the rate of depletion far exceeds their renewal rate. The aforesaid limitations, coupled with

their higher potential to produce GHGs, have forced nations across the globe to look for renewable and greener alternatives to safeguard the health of people and the environment. With the global efforts directed at attaining sustainable development in order to ensure a healthy planet for the current and future generations, developed and developing economies across the globe are gradually shifting their dependence from non-renewable to renewable resources. These paradigm shifts in global fuel usage patterns are in line with achieving the three pillars of sustainability, i.e., affordable energy, ensuring social stability, and mitigating climate change. It is believed that renewable resources could serve as effective alternatives to popular fossil fuels and other non-renewable sources, as they are more evenly distributed and cause fewer environmental and social concerns.

The need of the hour is the development of cleaner and greener fuels that can cater to the demands of the burgeoning population while at the same time being safer for environmental health by emitting fewer pollutants. Attempts are being made across the globe to produce fuels from renewable resources; hydrogen fuel cells are one such example. However, hydrogen fuel cells have limited usage owing to the sophisticated technology involved and the higher costs incurred in their production. Biofuels have emerged as smarter alternatives due to their lower cost, crude production methods, and ease of availability of raw materials.

Biofuels: trends and development

Biofuels are potent alternatives to conventional fossil fuels that can help mitigate climate change and the global warming crisis due to their cleaner and greener emissions. Biofuel is a type of fuel that is predominantly produced from biomass and largely used as a liquid fuel, either as such or in the form of various blends with petrol, i.e., bio-methanol, bio-ethanol, bio-diesel, and other gaseous fuels such as methane and biohydrogen. These biofuels carry remarkable benefits, both in terms of their enhanced economic returns and eco-friendly credentials. Blending bioethanol with gasoline enhances the ignition potential of engines owing to the additional oxygen contributed by bioethanol in such blends. The added oxygen aids in the complete combustion of fuel, leading to fewer emissions and lower air pollution. Further, these biofuels bear superior biodegradability and are nontoxic as well as have negligible sulphur content. The oxygen content of bioethanol is the main differentiating factor that owes it an eco-friendly tag viz conventional petrol. Bioethanol has an oxygen content of 10% to 45%, whereas petroleum has none. Bioethanol is found to be among the most encouraging alternatives that can serve as effective replacers for gasoline, satisfying the needs of the transportation sector and ensuring a greener environment. Globally, nations have started setting goals for meeting 5%–20% of the transportation fuel demands from sustainable sources within a 2-decade time frame, i.e., from 2010–2030. Currently, India's bioethanol production accounts for only 1% of the global production.

Bioethanol is fundamentally ethanol, i.e., colourless, eco-friendly, and renewable. It

is a high-octane fuel that has replaced lead as an octane enhancer in gasoline. Bioethanol is principally produced by the fermentation of sugars. Since bioethanol is produced from the fermentation of biomass as feedstock, the classification of biofuels is based on substrate sources (table.1). Using sugarcane as feedstock gave rise to the first generation of biofuels. However, the use of food resources to produce ethanol led to competition among the food and biofuel industries, negatively impacting food security. Further, it was also observed that the 1st generation feedstocks, mainly sugarcane, required huge quantities of soil, water, and chemical fertilisers for their cultivation, which came at significant ecological and financial costs.

Table.1

Classification	Feedstock
1st generation	Sugar crops (molasses)
2nd generation	Agricultural waste (lignocellulose) Forest residues Wood waste
3rd generation	Algae

The constraints posed by 1st generation biofuels paved the way for the development of 2nd generation biofuels, which used renewable biomass as feedstocks and rated higher on the eco-friendly index. The feedstocks for these biofuels largely included agricultural waste and forest residues, which was an added advantage as it gave an alternative option for the utilisation of these agricultural wastes and at the same time reducing the dependence on fossil fuels. Of all the types of biofuels, 2nd generation ethanol has evolved as a thriving transportation fuel that has the potential to abate global warming and environmental pollution. Hence, 2nd generation biofuel has attracted a lot of research interest which are aimed at making more economical methods of production by the development of strains.

Yet another breakthrough in the evolution of biofuels is the development of 3rd generation biofuels that use algae biomass as alternative feedstocks. Though at the initial phase of research, the technology is being developed at a rapid pace. Since these feedstocks do not compete with agricultural or feed production, these algal biomasses can be exclusively produced and exploited for bioethanol production. The superiority of algal biomass as feedstock is due to its enhanced fermentation efficiency owing to its zero-lignin content.

Renewable substrate for bio-ethanol production

There are several feedstocks that are being used and several others that have the potential to be exploited for ethanol production, but their use is limited by the low ethanol recovery and higher distillation costs, raising doubts about their feasibility for industrial purposes. Whey, a by-product of cheese, paneer, and casein production, is one such example. Whey being an agricultural waste, has the potential to serve as a feedstock for 2nd generation of biofuels. Since the manufacturing of cheese and

paneer began on large commercial scales the problem of disposal of large volumes of whey posed a challenge. Being rich in nutrients, at a time when technologies for recovering these nutrients were in the initial stages of development, the only option was to dispose of them in waterways or sewage systems. Gradually, as awareness grew regarding the threats to environmental health posed by untreated whey disposal, researchers started to look for efficient and safe methods of whey disposal. The fact that whey is composed predominantly of lactose, which can be fermented into ethanol, raised hopes for their usage as feedstocks for bioethanol. Since then, a lot of research has gone into developing alternative methods of whey utilization, bioethanol production is one of them. Whey can be a promising alternative substrate for commercial production of ethanol as it did not need any pre-treatment for breaking down of sugar compare to other agricultural waste.

Conclusion

As the world is heading towards a sustainable future, the demand for biofuels will always be on the rise. The gradual shift towards cleaner and greener fuels has set the tone for more scientific explorations into renewable sources for higher ethanol production. Whey is a potential substrate for ethanol production, being a renewable source, and its increasing production can provide a sustainable solution for the future's increasing demand for ethanol.[1]