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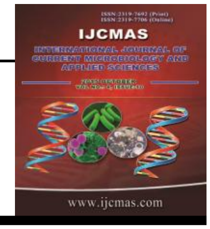

Review Article

Algal biofuel and their impact on Agriculture and Environment

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A B S T R A C T

Innovative approaches to clean energy development are vital as whole world looks for ways to reduce global warming pollution and fuel the clean energy future. Driven by population development and industrialization, demand for primary energy and food is increasing at an unprecedented pace. Fossil fuel consumption cannot be the solution for much longer, and existing renewable energy sources are still unable to offer scalable, competitive alternatives. Increasing food production requires arable land and fresh water but the intensive use of fertilizers produced from natural gas returns us again to the energy challenge. In the global energy crisis context, Biodiesel has core advantages over mineral diesel in that it is renewable, biodegradable, clean-burning, non-toxic and carbon neutral with respect to carbon dioxide related climate change. Photosynthetic microorganism microalgae and cyanobacteria as a potential source of biofuels because of their abilities to grow rapidly utilize non-arable land, non-potable water, waste streams and do not compete with world agriculture market. It can produce large amount of cellular storage lipids in the form of triacylglycerols (TAGs) which can be readily converted to biodiesel via a simple chemical transesterification reaction with zero emissions of both air pollutants and greenhouse gases. In above context present review present potential of photosynthetic microorganism as a source of biofuel and their impact on agriculture and environment.

Keywords

Microalgae, Biofuel, Biodiesel, Agriculture and environment

Introduction

Energy is an essential and vital component for development, and the global economy literally runs on energy. Fossil fuels, including oil, coal and natural gas, are providing about 85 % of energy globally. Due to the quick development of human activities and over consumption of fossil fuels, the need of energy is increasing continuously and this energy crisis is representing the major challenge of this century [1]. The need of energy is increasing continuously because of increase in industrialization and population. It has been expected in a report According to BP Statistical Review of World Energy 2010 that two main energy resources, crude oil and natural gas, may be diminished by 45.7 and 62.8 years, respectively and estimated energy consumption will be tripled in 2025 [2]. Today major requirement of energy is satisfied through the use of non renewable sources viz. petroleum, natural gas, coal, nuclear etc. and renewable sources viz. hydropower, wind and solar power [3]. Out of these, non renewable fossil fuel act as major contributor. To cope up with the crisis of fossil fuel in a sustainable manner, attempts have been made for alternative energy sources.

With rapidly rising world energy demand and high fossil fuel prices, an intense interest is being focused on the photosynthetic plants/organisms which can store lipids in the form of triacylglycerides (TAGs) and further transesterified to biodiesel (monoalkyl esters of long chain fatty acids), and gained popularity as an alternative to fossil fuels [4]. Therefore, raw materials containing higher content of fatty acid (FA) should be chosen for biofuel production [5]. In this regard biological sources viz. rapeseed, canola, sunflower, soybean oils, beef tallow and many other oils have been used for the production of bio-diesel esters, which are thought to be an alternative of fossil fuels [6].

But biodiesel derived from these edible crops, using today's technology, do not represent an effective alternative to substitute conventional fuel. The main drawbacks of these resources to be used as alternative of fossil fuels is that they compete with arable land, water and fertilizer, with low productivities against staple food crops [7, 8]. The consequences of this will result in the scarcity of food and the increasing of the world food prices. But as crop residues are an essential source of nutrients for plants, burning these crop residues means decreasing of organic matter in agricultural soils and using more mineral fertilizer like ammonium which is made under high energy use.

Now the third generation of biofuels /biodiesel is getting more attention. It is biodiesel made directly by photosynthetic microorganisms, mainly by cyanobacteria and microalgae acting as primary producer in the water bodies which cover more than 71% earth space [9] are considered as a promising option of sustainable biofuel production [10]. Some of the following reason support microorganism as good alternative for biodiesel production.

1) PSMs (Photosynthetic microorganism) which converts sunlight, water and CO_2 to sugars, from which macromolecules such as lipids and triacylglycerides (TAGs) can be obtained [6].
2) The microorganisms such as bacteria, yeasts, and algae can accumulate lipids at more than 20% of their biomass and are defined as oleaginous species [11].
3) It has been reported that biofuel production from photosynthetic microorganism is more advantageous as well as higher than best oil producing crop plants due to their rapid growth rates, relatively simple genetic system and limited effect on the food supply [12].
4) These photosynthetic micro organisms can grow in minimal nutrient supplements (water & photon, CO_2), their easy mass cultivation, extraction and purification procedures make them suitable for huge biodiesel production [13].

Although microalgal biofuels production has gained a renewed interest in recent years but is still not economically feasible due to several limitations related to algal culture and culture condition optimization, as a consequence the cost of microalgal biofuel is still much higher than conventional diesel [14].

One of the main barriers is the high producing cost due to our lacking of understanding of microalgal growth, metabolism and biofuel production. With these important issue, many researchers reported that the quantity and quality of lipids within the cell can vary as a result of changes in growth conditions (temperature and light intensity) or nutrient media characteristics (concentrations of nitrogen, phosphates and iron) [15,16].

With considerable evidence that fat accumulation takes place in many algae as a response to the exhaustion of the nitrogen supply in the medium [17, 18, 19]. It has been reported that a significant increase in lipid content up to 43% of dry cell weight (DCW) under nitrogen deficiency compared to 12.7% under control condition in *Scenedesmus obliquus* [6]. In a treatment of nitrogen depletion played significant roles in promoting microalgal FA synthesis, while fatty acid (FA) qualities were not changed much in *Haematococcus pluvialis* [5].

One of the report published in 2011 that the algae *Botryococcus braunii* contained high content (28.4-38.4%) of oleic acid under nitrogen limitation, but the content of total lipids and triacylglycerols did not change [6]. Biofuel policies are motivated by a plethora of political concerns related to reducing dependence on oil, improving the environment and increasing agricultural incomes [20, 21].

There are a number of reasons why governments are promoting biofuels even when subsidies are needed for them to be commercially viable. These include: Energy security: reduce dependence on imported petroleum; Climate change (decrease greenhouse gas emissions); Concerns about trade balances; Rural development and poverty reduction.

Algae as potential source for biofuel

Since last few decades there had been lot of emphasis and interest in the use of photosynthetic microorganisms (PSMs) as feedstocks for bioenergy production [22-27]. Microalgae are PSMs which converts sunlight, water and CO_2 to sugars, from which macromolecules such as lipids and triacylglycerides (TAGs) can be obtained [6]. The biofuel production from photosynthetic micro organisms is considered as a process to produce renewable energy for global warming mitigation [28] as PSMs are easy to culture, characterized by rapid growth and are able to grow in waters, unsuitable for human consumption [29]. There is keen interest in the development of technologies that harvest lipids from microalgae and convert them into diesel fuel [30-33].

Nutrient deprivation is one of the common stresses encountered by microorganisms in nature [34] Many micro algae have the ability to produce substantial amounts (20-50%) of triacylglycerols (TAGs) as a storage lipid under photo oxidative stress or other adverse environmental conditions [6]. Accordingly, much effort has gone into investigating lipid biosynthetic pathways in algae and several attempts have been made to increase their lipid productivity [26]. However much is still unknown about the biological triggers that cause the production of triacylglycerols [35] with thorough analysis of the underlying molecular mechanism currently in its infancy [13, 36]. Although fatty acid (FA) biosynthesis pathway genes have been all cloned and biosynthesis pathway was built up in some higher plants, the molecular mechanism for its regulation in microalgae is far away from elucidation [5]. Research in eukaryotic organisms, such as yeast, Arabidopsis, and mouse has identified several key genes in

TAG synthesis. One is a diacylglycerol acyltransferase (DGAT), which catalyzes the final step in de novo TAG synthesis, acylation of diacylglycerol to TAG [35], up-regulation of several genes viz. diacylglycerol:acyl-CoA acyltransferases in *Chlamydomonasin* due to nitrogen depletion involve in synthesis of starch and lipid [37], and in microalgae *Chlamydomonas reinhardtii* nitrogen deprivation led to a marked redirection of metabolism the primary carbon source, acetate, was no longer converted to cell building blocks by the glyoxylate cycle and gluconeogenesis but funneled directly into fatty acid biosynthesis [36].

Apart from nitrogen starvation effect on TAG production, many researchers also investigated other nutrients and factors having influence on TGA content of microalgal species. Effect of phosphate starvation on the lipid and fatty acid composition of the fresh water eustigmatophyte *Monodus subterraneus* and concluded that cellular total lipid content of starved cells increased, mainly due to the dramatic increase in triacylglycerols (TAG) levels [38]. Lei et al. [5] analyzed effect of different stressors like high temperature, high salinity, and nitrogen depletion treatments in expression of genes viz. acyl carrier protein (ACP), 3–ketoacyl–ACP–synthase (KAS), and acyl–ACP thioesterase (FATA) in algal specie *Haematococcus pluvialis* and found that these gene expression had significant correlations with monounsaturated FA (MUFA) synthesis and polyunsaturated FA (PUFA) synthesis [5]. Boyle et al. [35] reported that three genes encoding acyltransferases, DGAT1, DGTT1, and PDAT1, are induced by nitrogen starvation and are likely to have a role in TAG accumulation based on their patterns of expression. Efforts are also aimed to increase the lipid content of microalgal cells through overexpression of key enzymes in TAG biosynthesis, including diacylglycerol acyltransferase (DGAT), glycerol-3-phosphate dehydrogenase (G3PDH), and acetyl-CoA carboxylase (ACCase) [26, 35]. Researchers are experimenting with ways to grow photosynthetic microorganism's algae and cyanobacteria that can produce oil or hydrogen and other chemicals that can be converted into fuel (Fig 1).

Cyanobecteria as potential source for biofuel

Cyanobacteria are an ancient group of prokaryotic microorganisms around for nearly 3.5 billion years [40]**,** exhibiting the general characteristics of gram-negative bacteria. They are also named blue–green algae (BGA) because of the presence of phycocyanin and phycoerythrin which usually masks the chlorophyll pigmentation [41]. Cyanobacteria are considered as one of the unique and important primary producers in the biosphere, [42] as these prokaryotes possess chlorophyll *a* and conduct oxygenic photosynthesis [43] contributing a majority of the carbon fixation on earth, turning greenhouse gases into carbohydrates and lipids [44]. Their lipids are mainly in the form of diacylglycerols as the components of membranes, including monogalactosyl diacylglycerol, digalactosyl diacylglycerol, phosphatidylglycerol, and sulfoquinovosyl diacylglycerol [45]. The lipid and fatty acid content variation in cyanobacteria with respect to location and habitat and indicates that the total lipid content and their constituent fatty acid composition vary with their groups, location and the habitat [46]. Rajeshwari and Rajashekhar [47] also investigated biochemical composition of total carbohydrates, total proteins, total amino acids, total lipids, fatty acid profile and mineral content of seven species of cyanobacteria from the study area located at Western Ghats of Karnataka, They reported that with regard to the fatty acid composition, all the species showed higher levels of saturated fatty acids with the values ranging from 0.25 to 45.3%, whereas the levels of monounsaturated and polyunsaturated fatty acids (PUFA) were generally low [47].

In contrast to higher plants, greater variation in fatty acid composition is found in algal taxa. Some algae and cyanobacteria possess the ability to synthesize medium-chain fatty acids (e.g. C10, C12 and C14) as predominant species, whereas others produce very-long-chain fatty acids (>C20) [13]. These energy storage components form a potential feedstock of cyanobacteria can be converted into bio energy [10]. Cyanobacteria possess certain properties which have entitled them to be one of the most promising feedstock for bio energy generation (Fig 2).

Cyanobacteria have a high degree of morphological differentiation [48]. Morphological characters such as trichome width, cell size, division planes, shape and arrangement, pigmentation and the presence of characters such as gas vacuoles and a sheath are generally considered, but they remain difficult and confusing, leading to uncertain identifications and classification [49]. With advances in molecular systematics cyanobacterial phylogenies based on several genes viz. 16S ribosomal DNA (rDNA), *nif* H, and phycocyanin sequences being most prevalent these days [50]**.** The sequence of rRNA cistron is highly conserved and can be used with or without full genomic information for investigating microbial communities to indicate whether two organisms belong to different species [51]. Using denaturing gradient gel electrophoresis (DGGE) of specific 16S rRNA gene PCR products, showed significant differences in the cyanobacterial community structure between epi- and hypolimnetic waters [52]. In a similar type of study a molecular taxonomy based phylogeny on the concatenated sequences of seven gene loci including *psb*A, 16S rDNA, *rbc*L, *rbc*S, *rpo*C1, *cpc*B, and ITS1 between 16S and 23S rDNA was conducted depicting high acceptance such techniques to classify cyanobacteria, a comparatively difficult task [53]**.**

Indeed, bacterial growth depends on the availability of macronutrients that can serve as sources of carbon (C), nitrogen (N) phosphorus (Pi), and sulfur (S), in the absence or deprivation of any one of these essential macronutrients in the environment, cells cease to grow and divide [54, 55]**.** Various bacteria respond to nutrient limitation by entering a morphogenetic programme resulting in spore formation, cyanobacteria although do not sporulate, undergo substantial changes in response to nutrient starvation and exhibit sophisticated strategies that allow survival for long periods under stress conditions [55]. They are equipped with numerous mechanisms that allow them to survive under growth retarding conditions of nutrient starvation, some of which are unique to these organisms [54]. There are many report available regarding physiological and biochemical responses to changing abiotic factors including nutrient limitation, changes in hydrogen ion concentration, temperature etc. on cyanobacteria species.

Many researcher have been reported the effect of temperature and effects of light and dark incubation on the lipid and fatty acid composition of *Synechocystis* PCC6803 under isothermal growth conditions and after a downward shift in temperature [56, 57]. Although much is known about the physiological and biochemical changes of photosynthetic organisms in response to environmental factors, nevertheless little is known about the genetic regulatory networks that enable the organisms to respond to such environmental changes are still poorly understood [58].

Living organisms including cyanobacteria acclimating to environmental changes, primarily due to shifts in cell metabolism is determined mainly due to differential gene expression. Several methods viz. subtractive cDNA cloning, differential display, real time PCR and DNA microarrays are available and utilized from decades to obtain information about transcript levels in response environmental stress. Unfortunately cyanobacteria, lag behind in the use of these technologies, despite of their evolutionary, ecological, environmental and biotechnological importance [59]. Recently researchers' started to use these modern and authentic tools to study global gene expression patterns in several cyanobacteria too under different growth and environmental conditions [60]. Hihara et al. [61] evaluated the gene expression of unicellular cyanobacterium *Synechocystis* sp PCC 6803 using microarray during acclimation to high light intensity. Deshnium et al. [62] studied temperature-independent and dependent expression of desaturase genes (des) encoding delta 12 desaturase in filamentous cyanobacterium *Spirulina platensis* and reported that the desaturation of fatty acids might not be a key mechanism in the response to the temperature change of *S. platensis* strain. A similar attempt to examine the temperature-dependent regulation of the expression of the *des*A gene in cynobecteria *Synechocystis PCC6803* strain was performed and reported that the level of *des*A transcript increased 10-fold within 1 h upon a decrease in temperature from 36°C to 22°C [62, 63]. Park et al. [64] reported that the expression of the *isi*A gene (encoding chlorophyll protein complex) is essential for the survival of the cyanobacterium *Synechococcus* sp. PCC 7942 by protecting photosystem II from excess light under iron limitation. Wobeser et al. [65] measured genome-wide expression profiles of the *Cyanobacterium synechocystis* sp. strain PCC 6803 in response to gradual transitions between nitrogen-limited and light-limited growth conditions and found changes in the expression of several hundred open reading frames, genes with functions in photosynthesis and respiration, carbon and nitrogen assimilation, protein synthesis, phosphorus metabolism, and overall regulation of cell function and proliferation. Huang et al. [58] investigated global gene expression profiles of the *Cyanobacterium synechocystis* sp. strain pcc 6803 in response to irradiation with UV-b and white light and generated new insights into the integrated network of genes that adapts rapidly to different wavelengths and intensities of light, with a customized amplification library approach, and identified differential gene expression in the *Cyanobacterium Synechocystis* sp. strain PCC 6803, they reported that a number of genes, such as *isiA*, *idiA*, *psbA*, *cpcG*, and *slr*0374, expression either increased or decreased in response to iron availability [60]. Yin et al. [66] reported that the expression of *sll*1242 gene was upregulated in *Synechocystis* sp. PCC 6803 after transfer from 30 to 15°C and named it as *ccr* (cyanobacterial cold resistance gene)-1, required for cold acclimation of cyanobacteria in light. The strategies used by bacteria to survive in environments with high and changing salinities includes accumulation of compatible solutes viz. trehalose, proline, and glucosylglycerol (GG) that are proportional to the stress, that showed transcription of the *ggpS* gene encoding the key enzyme in GG synthesis is clearly induced after an osmotic upshift in *Synechocystis* sp. strain PCC 6803 [67]. Ribonuclease protection assays (RPA) is another powerful quantitative technique to study transcript analysis, with RPA, showing that Light repressed transcript, *lrt*A, from the cyanobacterium *Synechococcus* sp. PCC 7002 is more stable in dark-adapted cells than in cells exposed to light [68]. Iron (Fe) starvation frequently occurs in aquatic habitats and severely limits biomass production of photosynthetic organisms as Fe cofactors requirement of photosynthetic/ respiratory apparatus is especially susceptible to the deleterious effects of Fe limitation. Cyanobacteria respond to iron deficiency by expressing *Isi*A (iron stress-induced protein A), which forms a giant ring structure around photosystem I, works as an antenna to PSI , and may play a role in thermal dissipation of excess light energy [69]. Duhring et al. [70] showed that artificially over expressing *Isr*R (iron stress-repressed RNA), a cis-encoded antisense RNA transcribed from the *IsiA* noncoding strand, in *Synechocystis* sp. PCC 6803, under iron stress causes a strongly diminished number of *Isi*A–photosystem I supercomplexes, whereas *Isr*R depletion results in premature expression of *Isi*A. One of the report of two gene clusters with genes encoding proteins, which modify the electron transport chain (*Isi*A, *Isi*B, *Idi*C, and *Idi*A) as well as the transcriptional regulator *Idi*B, were found to be up-regulated in mesophilic fresh-water cyanobacterium *Synechococcus* elongatus PCC 7942 to iron starvation [71]. In general, the regulation of *Isi*A expression is still not well understood, Xua et al. [69] showed that pkn22 regulates *Isi*A and is required for cell growth under iron-limiting conditions.

Most cyanobacteria can use nitrate, nitrite, and ammonia as primary N-sources, although urea and organic N-compounds can also be used in some cases, while some cyanobacteria, mainly filamentous heterocystous strains, are additionally able to reduce dinitrogen to ammonia via nitrogenase [72]. In natural habitats, combined nitrogen is frequently a limiting nutrient, and therefore, cyanobacteria have developed multiple strategies to adapt to nitrogen deprivation. *Synechocystis* sp. strain PCC 6803, a non diazotrophic cyanobacterium, responds to the lack of combined-nitrogen sources by bleaching, a process known as chlorosis. Concomitantly with bleaching, the cells accumulate excess carbon fixation products in the form of intracellular polymer deposits composed of glycogen or poly hydroxyl alkanoates. In *Synechocystis* strain PCC 6803, the polyhydroxyalkanoate PHB (polyhydroxy-butyrate) was reported to accumulate under conditions of nitrogen or phosphate deprivation, upon the addition of acetate, or in response to a high photon flux density [73]. Investigation of the effects of nitrogen deprivation on the lipid metabolism of the cyanobacteria *Anacystis nidulans*, *Microcystis aeruginosa*, *Oscillatoria rubescens* and *Spirulina platensis*, and reported that either lipid content or fatty acid composition of these organisms was changed significantly under nitrogen-deprivation conditions [13, 74].

Current status of biofuel production in India

Many countries have adopted aggressive policies that promote biofuels as a substitute for fossil fuel in transportation. India is the sixth largest and one of the fastest growing energy consumers in the world due to raising population and its consumption power [39]. Since the beginning of the 2000s, the Government of India and, to a greater extent, various state governments have promoted the production and consumption of biodiesel. Indian biofuel policies evolved over a decade and the adoption of the National Biof uel Policy in 2009 is a milestone for the development [75]. The basic sources of the energy are petroleum, natural gas, coal, hydro and nuclear power [3]. In Indian prospective, liquefied petroleum gas (LPG), electricity, kerosene, firewood including coal is the main energy source. Even electricity is not yet available in a few villages and the gas connection is being demanded by a majority of households in cities and towns. Also, recent increased prices of the petroleum products are adversely affecting the livelihood [76]. At present, the supply of bioenergy as one of the important challenges, because India produces 30% of its annual crude oil and petroleum products requirement of 105 million tonnes and meets 70% of its requirement through import with 150 to 200 tonnes of ethanol used annually for fuel blending. This demand (annual rate of 4.8%) is estimated to grow to 5.8% till 2030 [77]. Globally the search for replacements for fossil fuel has also increased and biofuels such as bioethanol, biodiesel, etc. derived from terrestrial non-edible crops have emerged as short term solutions, however, they carry significant sustainability issues coupled to their use [78, 79]. Then bio-fuels promise to be an appropriate option to be fixed as a solution to these problems and have been developing in stages [80]**.**

The major feedstock used for first generation biofuel (bio-ethanol) production in India is sugarcane molasses which is not available in plenty amount to even meet the demand for chemical and pharmaceutical industries, similarly there are several constraints in industrialization of second generation bio fuel production (Lignocellulosic ethanol) such as cost of the process and enzyme. But none of them can provide an efficiently transportable fuel to power engines in the same manner as fossil fuels. Then the research has been shifted towards the third generation biofuel through photosynthetic microorganism (micro-algae/bacteria) appears as the best renewable source in our country [81]. Many microalgae and cyanobacteria are known to accumulate several types of lipids to the tune of 60% by dry weight and are now considered as a promising alternative to fossil fuel [6, 7, 82]. However, the cultivation methodologies are yet to be established for their economic feasibility as cultivation of microalgae for lipid/hydrocarbon production involves various other integrated aspects [83]. Cultivation of microalgae in India dates back to raceway pond cultivation of *Spirulina* for food and essential metabolites. A large number of fresh water and marine microalgae are being identified for biofuel production based on their lipid content and *Botryococcus sp*. for hydrocarbon content [7, 84]. Commercial exploitation of algae for biodiesel production can be beneficial environmentally, socially and economically. Algae can grow in minimal nutrient supplement and beneficially harvest the light energy and can double their biomass within 24 hours. It is for this reason that these photosynthetic microorganisms are capable of synthesizing more oil per acre than the terrestrial plants which are currently used for the extraction of biofuels [85].

The idea of using micro algae as sources of fuel is not new, but it has only recently received a lot of attention as a new biomass source for the production of renewable energy because of the escalating price of petroleum and, more significantly, the emerging concern about global warming that is associated with burning fossil fuels [86]**.** Micro algae can provide several different types of renewable bio-fuels such as methane produced by anaerobic digestion of the algal biomass [87]**,** biodiesel derived from micro algal oil [85, 88] and photo biologically produced bio-hydrogen [89, 90]. The potential of microalgal biodiesel in comparison to the agricultural crops and its prospects in India has recently been reviewed by several workers [80, 82].

Advantage of biofuel

There are many advantages of biofuels over fossil fuels that make the alternative fuel source an attractive option now and in the future. Biofuels have been in production for the last few decades and have really begun to take off with the awareness of global warming going around the world. Here are some of the benefits of biofuels over fossil fuels.

Lower emissions

One of the biggest knocks against fossil fuels is that they give off toxic emissions. These pollutants, called greenhouse gases, trap the sun rays inside our atmosphere. This causes global warming. Biofuels do not release as much carbon as fossil fuels do, and because of this, there are fewer harmful emissions out of biofuels.

Renewable

Being made from organic materials, and even organic waste, there is practically an infinite amount of biofuel available. We can grow it ourselves by producing corn, which is currently the product most used to make biofuel.

Using waste means we don't need to lose energy getting rid of our waste, but reverse the process and make sure we get all the energy out of it that we can. This may be one of the biggest reasons that biofuel are getting more popularity.

Biodegradable

Biofuels are made out of organic substances, which are biodegradable. These fuels are much less toxic in the event that something happens like the oil spills that occur, these spills are made worse due to the fact that it is oil. If these spills were of biofuel, they would break down naturally, and the environment would not be affected nearly as much.

Safety

Finding these fossil fuels in the earth is dangerous and costly procedure. There is drilling, mining and other activities that are done to get to the core of traditional oil reserves. Comparatively, when we grow the organisms for biofuel production on a farm, its much safer and not as much as dangerous.

Impact of biofuels on agriculture sector

The increasing thirst for energy to fuel its fast growing economy has made world keen to explore the potential of modern form of bioenergy, biofuel [91]. Biofuels from land-rich tropical countries may help displace foreign petroleum imports for many industrialized nations, providing a possible solution to the twin challenges of energy security and climate change. But concern is mounting that crop-based biofuel will increase net greenhouse gas emissions if feedstocks are produced by expanding agricultural lands [92]. The debate over the direct and indirect impact of increased demand for biofuel (defined here as bioethanol and biodiesel), especially from rich countries, on the global food prices has reached unprecedented levels over the past few years [93]. World-wide production of biofuel is growing rapidly. From 2001 to 2007, world ethanol production is tripled from 20 billion liters to 50 billion liters and world biodiesel production grew from 0.8 billion liters to almost 4 billion liters [94]. The various calculations of the impacts of biofuel production on the mid-term projections of food and agricultural commodity prices are difficult to reconcile [93]**.** It is argued that developing countries could be significantly more competitive in producing biofuel than industrialized countries, due to relatively low costs of production and the availability of cheap agro-ecologically suitable land for the cultivation of biofuel feedstocks. Although this trend could provide developing countries with much-needed international trade and investment, it does pose a number of challenges. When selection of crop or use of land and farmers can obtain greater profits for use of their land for biofuel than for food, this risk becomes apparent. Price increases already have occurred in biofuel feedstock markets for sugar, corn, rapeseed oil, palm oil and soybeans [95].

In contrast, urban and rural poor in food-importing countries will pay much higher prices for basic food staples and there will be less grain available for humanitarian aid [96]. From 2006 to 2008, in spite of worldwide record crops, global prices for traded food commodities, such as wheat, reached record price highs. Many countries have adopted aggressive policies that promote biofuels as a substitute for gasoline in transportation. For instance, more than 10% of US gasoline use now comes from corn ethanol. This share is expected to rise to 30% in 2022 [97]. These and subsequent food price spikes have had disturbing consequences for poorer segments of society, who spend a disproportionally high share of their monthly income on food to meet their basic nutritional needs [97, 98]. There is great international concern that the expanded use of first generation biofuel feedstocks of crops and land used for food production will have serious adverse effects on agriculture and food supplies [95]. At a global scale, land is becoming a scarce resource, asserting the need for more efficient land use allocation and innovation in agriculture [99]. Another difference between food and energy crops is the relation between yield and input. For food crops, yield is the primary concern. To ensure the yield, people have been willing to increase the input of water, fertilizer, labor, and machinery [100]**.** Many biofuel crops require large amounts of water for their cultivation, particularly harmful in areas where water is scarce. Depletion and contamination of water supplies can have profound effects on human and animal health [95]. Then international attention was refocused on the relationship between biofuel and food commodity prices when a leaked internal World Bank study attributed 70–75 per cent of the 2006–2008 increases in food commodity prices to biofuel. Because the existing crops cannot meet the goal of sustainable bioenergy production, new energy crops have been explored. To overcome the problems mentioned above, the new crops should be grown on marginal land unsuitable for food production. They should have a high biomass yield with relatively little irrigation or fertilization. Energy input involving tillage, planting, harvest, storage, and transportation should be minimized. These crops, domesticated specifically for energy production, are referred to as second-generation energy crops [101, 102, 103].

A potential benefit associated with biofuel is their positive impact on agricultural employment and livelihoods of small farmers or poor (landless) workers in rural areas but it has adverse effect on world agriculture market. Biofuels have the potential to create jobs in rural areas, but a large share of these jobs will only be for low-skilled seasonal agricultural workers. These workers, who are often migrants, are especially vulnerable. There are still too many reports of forced labor, child labor and dangerous working conditions in sugarcane fields and processing facilities. Agricultural workers also face health risks, primarily due to the inappropriate use of agrochemicals. Often, they are not informed about the risks of their work, nor provided with safety equipment. Social criteria including better working conditions should be a component of the standards for biofuel production and trade. Also the disadvantage associated with it is acquiring of agricultural land [104]**.** The consequences of this will result in the scarcity of food and the increasing of the world food prices. The second generation of biofuels was made out of residues from crops, animals, timber and food. This application reduces the disadvantage competition with human food. But the crop residues are an essential source of nutrients for plants. Burning these crop residues means decreasing of organic matter in agricultural soils and using more mineral fertilizer like ammonium which is made under high energy use. Now the third generation of biofuel /biodiesel is getting more attention. It is biodiesel made directly by microorganisms, mainly by cyanobacteria and microalgae. Comparing with the conventional oil crops, microorganisms are more attractive as feedstock for biodiesel production, due to their high photosynthesis efficiency and lipid content. Microorganisms such as algae and cyanobacteria are photosynthetic, acting as primary producer in the water bodies which cover more than 71% earth space [9]**.** They can use sunlight to convert carbon dioxide to different hydrocarbons including lipids, and it has been reported that algal lipid has been a potential substitute of fossil fuel in future substitute [105-108] due to their accumulation inside the cell at the end of growth stage [109, 110, 111]. Apart from this, these photosynthetic micro organisms can grow in minimal nutrient supplements (water & photon, CO_2), their easy mass cultivation, extraction and purification procedures make them suitable for huge biodiesel production [13]**.** Because agriculture affects both climate change and food production in developing countries will be adversely affected by afro based biofuel, especially in countries that are already climate-vulnerable (drought, flood and cyclone prone) and that have low incomes and high incidence of hunger and poverty. There is a positive impact of growing biofuel from these photosynthetic microorganism in developing countries can employ many small farmers or (landless) poor workers in rural areas, thus having a positive approach for rural development and livelihoods. The benefits of biofuel over traditional fuels include greater energy security, reduced environmental impact, foreign exchange savings, and stop the socioeconomic issues [111].

Impact of biofuels on environment

Since the beginning of the automobile era a century ago, oil has had a near monopoly as an energy source for transportation. In 2007, petroleum products accounted for 95% of world transportation energy [112]. An intensive search for alternatives is now underway, driven by a variety of concerns including volatile oil prices, increased global demand, reliance on imports from politically unstable regions, and recognition of the harmful effects of GHG and local air pollution [113]. Many countries plan to improve their energy and economic security and reduce their greenhouse gas (GHG) emissions to abate global climate change. Towards these ends, researchers are developing sustainable liquid transportation fuels from biomass (biofuel). These fuels would replace petroleum transportation fuels and would contain atmospheric (biogenic) carbon rather than fossil carbon, thus addressing GHG emissions concerns [114].

Current energy policies address environmental issues including environmentally friendly technologies to increase energy supplies and encourage cleaner, more efficient energy use, and address air pollution, global warming, and climate change [115]. Conventional fuels are responsible for issuing the atmosphere of significant amounts of pollutants and greenhouse gases that contribute to what is today called global warming. The greenhouse effect is a natural phenomenon by which a part of the terrestrial infrared radiation is retained by the earth's atmosphere. The effect is due to greenhouse gases that the radiation reflected back. In the 1990s, The International Panel on Climate Change distinguished three main options for the mitigation of atmospheric CO_2 concentrations by the agricultural sector: (1) Reduction of agriculture-related emissions, (2) Creation and strengthening of C sinks in the soil, (3) Production of biofuel to replace fossil fuels

Pre-occupation with global energy supplies and climate change in the global, and a desire to improve the balance of trade and capture value in the emerging carbon market by developing countries, together place biofuel firmly on the map of global land use change [116, 117]. Among these many alternatives are liquid biofuel [112, 113]. The belief that biof1uels can mitigate climate change has driven governments around the world to promote the production of ethanol and biodiesel through policies that guarantee markets and offer incentives to producers and consumers [118]. One of the primary justifications for a shift to biofuels as an alternative energy source has to do with the climatic benefits that are anticipated to occur from the substitution of fossil fuels, whose combustion results in large net CO_2 emissions, to fuels whose combustion releases gases sequestered through cultivation and which are therefore considered greenhouse gas (GHG) neutral. This promise of greener energy for transport has led to the inclusion of biofuel in alternative energy targets in many industrialized countries, notably the USA and the EU [117]. The role of biofuel in the mitigation of climate change is highly contested. A key issue is the extent to which biofuel will reduce carbon dioxide emissions if the cultivation of their feedstocks results in clearance of stocks of carbon from forests (deforestation). Associated with this are questions about the loss of locally valuable forest goods and services. If cultivated land is used instead, there is a potential loss of food production and reduced food security, and there are risks that any form of biofuel production may change traditional land holding patterns, social relations, and livelihood opportunities, particularly if large-scale production replaces small-scale farming [119]. Soil erosion is one of the biggest environmental problems in the world. By increasing the productivity of cultivated lands, biofuel contribute greatly to the acceleration of this geological phenomenon. With the association of these problem researchers around the world are developing sustainable liquid transportation fuels (biofuels) to reduce petroleum consumption, large scale land use and greenhouse gas emissions. Microalgae are attractive source, they promise large yields per acre compared to grasses, grains and trees, and because they produce oils that might be converted to diesel and gasoline equivalents or more. It takes considerable energy to produce algal biofuel with current technology, thus, the potential benefits of algal biofuel compared to petroleum fuels must be quantified [114]. Biofuel require inexpensive biomass feedstock, but the land, water, and nutrient needs of biofuel crops, combined with those from feed and food crops, must be consistent with available resources. Wood based biofuel also cause harmful adverse affect in the form of deforestation and green house effect. Photosynthetic microorganism microalgae and cyanobacteria experiments have shown large productivities compared to terrestrial cellulosic plants like grasses, grains and trees. This trait, if realized in reliable agricultural processes, offers large biomass yields per acre. Also, algae can store energy in lipids that might be converted to diesel and gasoline equivalents using current infrastructure [114] and play a key role in carbon recycling.

Conclusion

Today world is facing three critical problems like high fuel prices, climatic changes and air pollution. Currently there are several important problems to be resolved worldwide high need for energy, high depletion of non-renewable energy recourses and high local and global environmental pollution. Biofuel include energy security reasons, environmental concerns, foreign exchange savings, and socioeconomic issues related to the rural sector. Biofuel have been part of the energy discussions for decades. However, over the past few years, discussion and action has increased with rises in crude oil prices. But in addition to prices, there are a number of reasons why governments are showing interest in biofuel even when subsidies are needed to make them commercially viable. These include energy security, concerns about trade balances, desire to decrease GHG emissions and potential benefits to rural livelihoods. The various calculations of the impacts of biofuel production on the mid-term projections of food and agricultural commodity prices are difficult to reconcile. These and subsequent food price spikes have had disturbing consequences for poorer segments of society, who spend a disproportionally high share of their monthly income on food to meet their basic nutritional needs. There is a biggest controversy regarding first and second generation biofuel due to their negative impact on agriculture, food security, deforestation and environment. But the third generation of biofuel provides a positive impact. Use of these photosynthetic microorganisms' microalgae and cyanobacteria for biofuel production in developing countries can employ many small farmers or (landless) poor workers in rural areas, thus having a positive approach for rural development and livelihoods. The benefits of biofuel over traditional fuels include greater energy security, reduced environmental impact, foreign exchange savings, and stop the socioeconomic issues and carbon sequestration.

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