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OVERVIEW OF PRESENT AND FUTURE SCENARIO OF *JATROPHA CURCAS:* A SOURCE OF RENEWABLE FUEL IN BANGLADESH

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Abstract- *Due to the rapid depletion rate and skyrocketing price of conventional fuel the engine and fuel researchers all over the world are being interested about biodiesel as an alternative source of energy. Jatropha curcas is one of the suitable sources of biodiesel as it is environment-friendly, non-edible and does not conflict with food. Moreover, Jatropha biodiesel can be used as a sustainable diesel fuel with similar or better performance in diesel engine. This paper reviews the potentiality of Jatropha curcas as a source of biodiesel and overviews from the present status to future prospects in Bangladesh. By promoting Jatropha curcas, Bangladesh can reduce importing a huge amount of petroleum products from foreign countries and can become more economically stable.*

Keywords: Alternative source of energy, Biodiesel, *Jatropha curcas* and Bangladesh

1. INTRODUCTION

The world is running by energy. The huge demand for energy has helped economic growth but creating quick depletion of conventional fuels. To meet the energy security and environmental consideration may lead different countries to change their energy policies [1]. It is the high time to find out alternative energy sources which are non-conventional as well as environment-friendly. Biodiesel, a fuel made from vegetable oil / waste cooking oil / fats (animal or human fat) is one of the toppers in this list. In 1900, Sir Rudolph Diesel invented a diesel engine, which was operated with vegetable oil [2].

*Jatropha curcas*is a non-food crop plant and fuel from this plant can be considered as an alternative fuel.*Jatropha* biodiesel can be considered as recyclable, renewable and environment-friendly fuel [3]. By blending *Jatropha* biodiesel in some certain percentages (5%, 10%, 15% and 20%) with petro-diesel [4], it can be alternative to fossil fuel for transport sector [5]. *Jatropha curcas*is one of the potential sources of biodiesel. The seed of *Jatropha curcas* contains 50% to 60% oil, which can be processed by transesterification process [6]. This is the process where the oil/fat (triglyceride) is chemically reacted with alcohol in presence of NaOH/KOH catalyst to produce ester and the only byproduct glycerol [6-8]. Transesterification is done because the vegetable oil cannot be used directly in engines as they have higher viscosity that causes problems like engine deposits, piston ring sticking, injector coking and eventually reduction in efficiency etc. which are highly unexpected [9]. *Jatropha* is a draught resistant plant and can grow in degraded or arid soil; it can reclaim the unfertile lands. The seed cake obtained by *Jatropha* extraction can be used as animal and fish feed and for biogas production [10]. Developing countries like Bangladesh will be facing the scarcity of fuel in near future. Bangladesh imports 37 lakh tons of fuel yearly among which 24 lakh tons are diesel fuel entirely imported from India, Saudi Arabia, Kuwait and UAE which costs about 2 billion USD [11].

Bangladesh is an agriculture-based country, where any edible or inedible seeds can be grown. In this context, a huge amount edible or inedible oil seeds can be cultivated in the used or unused land. According to a survey, it was estimated that about 2387,500 ton non-edible oil seeds can be produced per year that will supply 1322,235 ton oil leading with 1001,881 ton biodiesel by plantation of non-edible oil seed in the sides of rail and road [12]. At present, some initial projects are going on for *Jatropha* cultivation but Bangladesh needs to produce biodiesel commercially. This paper overviews the present status and future prospect of biodiesel production from *Jatropha curcas*in Bangladesh. The need of alternative fuel and cost analysis for biodiesel production from *Jatropha* is also discussed in this paper. Further study is needed for introducing the path to produce biodiesel commercially at low cost.

2. CULTIVATION OF *JATROPHA CURCAS*

Jatropha belongs to the family Euphorbiaceae, is a nonedible renewable plant and very undemanding of any specific climate and soil [13]. *Jatropha* is a large shrub, usually having a height of 3 - 5 m, but can attain a height up to 8- 10 m under favorable conditions. Flowering usually occurs during the wet season but in permanently humid regions, flowering occurs throughout the year. Flowers are usually monoeceious, unisexual and greenish yellow colored [14]. The flowers are fertilized by insects particularly by honey bees. After 3-4 months of flowering the seeds become mature. The seeds are black and the weight per 1000 is about 727 g; there are 1375 seeds per kg in average [15]. The growth of *Jatropha curcas*is seen from sea level to an altitude of 1400 m and necessitates a minimum annual rainfall of 250 mm, an optimum annual rainfall of 900 to 1200 mm. *Jatropha* is a draught resistant plant that grows in marginal and waste lands and does not contest with food production [16]. It shows best performance under the condition of warm temperature. Output of *Jatropha* depends on some aspects like precipitation rates, soil moisture, soil fertility, plant age, genetics and various management factors including fertilization, trimming and disease control [17]. Its productive period is also long about 30-50 years. The seeds are toxic because they have toxalbumine called curcine [18]. *Jatropha* oil contains approximately 47.25% crude fat, 24.60% crude protein and 5.54% moisture contents [15].

3. TRANSESTERIFICATION PROCESS

Biodiesel from *Jatropha curcas* oil can be produced by a well-known method termed transesterification where an alcohol is displaced from an ester. The purpose of this process is to reduce the viscosity of triglycerides [19]. After this reaction, triglycerides are converted into alkyl esters and the only byproduct of this chemical reaction is glycerol, which can be used for commercial purposes. Heat and a strong base catalyst such as NaOH/KOH is required to progress the reaction quickly. Simple alcohols like methanol or ethanol, can be used in transesterification process [20]. The general transesterification reaction is as follows:

$CH_2OOC\text{-}R_1$		$R_1\text{-}COO\text{-}R'$	$CH_2\text{-}OH$
|	Catalyst		|
$CH_2OOC\text{-}R_2$	+ $3R'OH \rightleftharpoons$	$R_2\text{-}COO\text{-}R'$ +	$CH\text{-}OH$
|			|
$CH_2OOC\text{-}R_3$		$R_3\text{-}COO\text{-}R'$	$CH_2\text{-}OH$
Triglyceride	Alcohol	Fatty acid Esters	Glycerol

Fig.1: Generalized transesterification reaction [21].

4. ADVANTAGES OF *JATROPHA* CULTIVATION; OIL/BIODIESEL AS FUEL

The following are some advantages, which *Jatropha* offers:

- The production cost is not too much high [22].
- It is draught resistant and can be cultivated in marginal lands to control soil erosion and to reclaim lands [22].
- The plant can be used as a hedge to repel animals and insects [22].
- It can be grown in almost any type of soil and climate [22].
- It does not necessitate any type of fertilizer [22].
- No need to displace the food crops [22].
- *Jatropha* seed oil can produce large amount of biodiesel (seed yields approximately 55-60%oil) [22].
- A substantial amount of wood can be obtained from *Jatropha* plantation [23].
- *Jatropha* wood is a light in wood [23].
- *Jatropha* oil is used for cooking and lighting purpose as a potential domestic fuel [24].
- The oil can be commercially used for producing soap, medicine, pesticides, cosmetics, toothpaste, embalming fluids, pipe joint cement, cough medicine and tobacco (as a moistening agent) [24].
- The bark of *Jatropha* can be used as an active anti-microbial as well as anti-cancerous agent and latex are used to stop bleeding [25].
- Leaves are used to cure various ailments like dysentery, colic, fever, joint rheumatism, jaundice, leukemia, malaria, fever, mouth infections and guinea worm sores [25].
- Roots are used as an antidote for snake bites and works against dysentery and diarrhea [25].
- Biodiesel byproduct like glycerin is profitable itself [26].
- The byproduct of *Jatropha* seeds can be used as domestic animal food, fish feed and organic fertilizer [26].
- Without any modification *Jatropha* biodiesel can be used in diesel engine and extend the life-time [27].

5. DISADVANTAGES

- It is found that *Jatropha* seeds and leaves are toxic to human and domestic animals [18].
- Use of huge land for cultivation, it can compete with food production [18].
- Compared to diesel fuel, the viscosity of biodiesel is about 11 to 17 times higher [22].

6. EMISSION CHRACTERISTICS OF *JATROPHA* BIODIESEL/OIL

Emissions of diesel engine can be controlled by using biodiesel. It is found that biodiesel usually emits small amount of unburned hydrocarbons (HC), oxides of nitrogen (NO_x), carbon monoxide (CO), carbon dioxide (CO_2) and smoke/soot.

Biodiesel emits lower HC emissions compared to diesel fuel [28-38]. The two major reasons pointed out for lower HC emissions are higher cetane number and presence of higher oxygen content than diesel. The higher cetane number reduces the combustion delay and the higher oxygen content enhances the possibility of cleaner combustion which subsequently decreases the amount of HC emissions [36, 38]. Obtaining opposite result has been possible by using *Jatropha* biodiesel/oil [39, 40].

In most studies the use of biodiesel/oil instead of road diesel increased the NO_x emissions, also found higher NO_x emissions with higher exhaust gas recirculation (EGR) rate (over 25% EGR rate) [28, 29, 31, 33-35, 38, 41, 42]. This is because biodiesels are oxygenated fuels and they produce high temperature from better combustion [41]. The decrease in NO_x emissions has also been shown by some researchers [36, 37, 40, 43]. An experiment conducted by Rao with preheated *Jatropha* biodiesel (JBD_PH) and found a reduction in NO_x emissions [38].

Some articles indicated decrement in CO emissions [28, 30, 32, 33, 35, 36, 41-43]. Similar to HC emissions the reduction in CO emissions occurs due to the presence of oxygen content and higher cetane number [36]. A reduction of approximately 48% CO emissions was noted with respect to diesel for *Jatropha* Methyl Ester (JTME) at 100% load [41]. However, opposite trends in CO emissions were also reported in the articles [31, 37, 39, 40]. The high viscosity of vegetable oils can be the reason as it makes difficult to atomize the vegetable oils [40].

Studies [33, 38, 43] revealed the reduction in CO_2 by using biodiesel. It has also been reported that the biodiesel blends produced 2% to 8.9% less CO_2 emissions than those of diesel fuel from no load to full load conditions[33].However, some researchers reported an increase in CO_2 emissions with biodiesels/oils [29, 35, 37, 40, 42].

Many literatures showed the decreasing nature of smoke/soot [28, 30-32, 36-38, 41, 43] emissions with *Jatropha* biodiesel/oil compared to that of diesel fuel. A maximum of about 78% soot was reduced at 75% load by using JTME [41]. Smoke emissions increase with increased brake power and decrease with increased biodiesel blend percentages[32].

Table 1 shows a comparison of some representative emissions with diesel fuel and biodiesels/oils.

Table 1: Emissions analysis using *Jatropha* biodiesel for different conditions

Engine type/model	**Conditions**	**Fuels**	**NO_x emissions**	**HC emissions**	**Smoke or soot emissions**	**References**
Single cylinder with four strokes	Full (100%) load	Diesel	237 ppm	56% reduction by JME	Decreased by 20%	[37]
		JME (*Jatropha* Methyl Ester)	178 ppm			
Single cylinder with four strokes	3/4 of load	Diesel	782 ppm	87 ppm	3.3 BSU	[36]
		JO (*Jatropha* Oil ester)	768 ppm	71 ppm	2.9 BSU	
Single cylinder with four strokes	Approximately atfull load	Diesel	-	About 1.15 g/kWh	About 18% opacity	[39]
		20% *Jatropha* oil blend (J20)	-	About 1.25 g/kWh	About 21% opacity	
Four cylinder with four strokes	100% of rated load	Diesel	About 3.5 g/kWh	About 0.185 g/kWh	About 20% opacity	[29]
		50% *Jatropha* oil (V50)	About 4 g/kWh	About 0.18 g/kWh	About 28% opacity	
Single cylinder with four strokes	100% load	Diesel	Approximately 690 ppm	Approximately 32 ppm	206 mg/m^3	[28]
		100% *Jatropha* Methyl Ester (JTME)	Approximately 820 ppm	Approximately 16 ppm	51 mg/m^3	
Single cylinder with four strokes	100% load	*Jatropha* methyl ester (JTME) with respect to diesel	Increased by about 15%	Decreased by about 44%	Decreased by about 75%	[41]
Single cylinder with four strokes	Maximum power output at rated speed (3.72 kW)	Diesel	About 580 ppm	About 175 ppm	About 4.2 BSU	[38]
		Jatropha biodiesel (JBD)	About 610 ppm	About 160 ppm	About 3.2 BSU	
AVL-make, 3-cylinder	8-mode cycle, BMEP = 5.9 bar, and 1800 rpm	20% *Jatropha* biodiesel (JB20) with respect to diesel	Increased by about 20.5%	Decreased by about 32%	Decreased by about 79%	[31]

Engine type/model	Conditions	Fuels	NO_x emissions	HC emissions	Smoke or soot emissions	References
Kirloskar with single cylinder (Model - DAF8)	1500 rpm and high load	D100	About 2000 ppm	About 76 ppm	Approximately 95% opacity	[40]
		100% *Jatropha* oil (J100)	About 1800 ppm	About 80 ppm	Approximately 85% opacity	
Single cylinder kirloskar with four strokes	Output power of 3.5 kW and 1500 rpm	Diesel	About 830 mg/kg	-	Approximately 12.2% Bosch	[43]
		50% esterified *Jatropha* oil	About 780 mg/kg	-	Approximately 11% Bosch	
Single cylinder with four strokes	Output power of 4 kW	Diesel	About 1590 ppm	Approximately 41%	About 26% opacity	[33]
		20% esterified *Jatropha oil* (B20)	About 1600 ppm	Approximately 38%	About 30% opacity	
Four cylinder (indirect injection)	4000 rpm	Diesel	About 248 ppm	About 7.5 ppm	-	[35]
		10% *Jatropha* methyl ester (JB10)	About 270 ppm	About 5.2 ppm	-	

7. PRESENT AND FUTURE SCENARIO OF BIODIESEL PRODUCTION IN BANGLADESH

Due to the fossil fuel depletion, skyrocketing price of petroleum diesel, high emissions of CO_2, deforestation and global warming, Bangladesh will be facing serious problems like power crisis, environmental degradation and low production rate in near future. Gas and electricity cannot expand appreciably due to their inadequate production and requirement of huge capital. Renewable energy can be a great solution of this energy crisis and other economic and environmental problems by producing more electricity at lower cost in Bangladesh [44]. The renewable energy sources include biomass, solar, hydropower, wind and tidal energy need to be exploited. Biodiesel and bioethanol production are still in their primary stage in Bangladesh, although their future is auspicious [45].

About 32 countries around the world including Nepal, Sri Lanka, China, Mexico, Cambodia, Tunisia, South Africa and Egypt are cultivating *Jatropha*. India is planning to depend about 100% on *Jatropha* in near future [46]. During 2009, in a project of Bangladesh Atomic Energy Commission of Plant Biotechnology Division, *Jatropha* and *Cassava* were planted as a future biodiesel project. However, due to absence of proper policy and adequate funding, the project did not progress. KhwajaAgri-Horticultural Research Centre (KAHRC) first produced biodiesel from *Jatropha* seeds at the Bangladesh Ansar and VDP Academy, Gazipur [45]. In 2008, the Bio-Fuel Development Company started working in Bangladesh for raising awareness among farmers and policymakers about *Jatropha* cultivation and producing biodiesel. The *Jatropha* Cultivation and Research Development Centre at Mymensingh was also opened by this company [46].

Bangladesh requires 37 lac metric tons of energy fuel annually of which 24 lac metric tons is diesel and the rest is petrol and octane. It costs 21 thousand crore taka annually. By proper production of biodiesel from *Jatropha*, Bangladesh can save huge amount of foreign currency. Indeed, by promoting *Jatropha* appropriately, it can also meet entire country's requirement [46].

Major hindrances of biofuel production are absence of biofuel crop domestication, recalcitrance of lignocellulose, low oil yields from crop plants including chemical and enzymatic breakdown. A huge fund should be collected from international organizations from carbon fund to facilitate biofuel sector by government and non-government organizations. Small and medium size biodiesel industry should set up in Bangladesh to meet the growing demand of energy and heavy requirement on imported oil for economic and environmental development. Progressive technologies are imperative for both sustainable development and social development for biofuel production in Bangladesh [45].

8. CONCLUDING REMARKS FROM THE OVERVIEW

Jatropha curcas, a sustainable resource, can be a suitable substitution to petroleum based diesel fuel. Developing countries are replacing fossil fuel with *Jatropha* biodiesel for its environmental benefit and renewable nature. Among all other biodiesel resources, Bangladesh should start producing *Jatropha* based biodiesel as *Jatropha* can be grown with comparatively less effort. Moreover, *Jatropha* biodiesel can reduce the emissions of different harmful gases that are produced from combustion. Most of the published reports stated higher NO_x emissions from biodiesel combustion. However, a 56% of unburnt HC [37] was found to be reduced with *Jatropha* methyl ester and about 48% of CO emissions was reduced at full load [41]. Considering the fact of fuel price hike, depletion of fossil fuel and environmental pollution, different government and nongovernment organizations of Bangladesh should start working together on biofuel/biodiesel production immediately. Investments for biodiesel industries and plantation of *Jatropha curcas* in the available wastelands is also desired. It is possible to save a huge amount of foreign currency even fulfil entire country's requirements by the production of *Jatropha* commercially. In summary, for biofuel production, Bangladesh should take steps for cultivating *Jatropha* and other non-edible oil seed plants instantaneously.

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