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Advancement of Biodiesel in Bangladesh

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***Abstract*:**–This paper presents an overview of Biodiesel resources and research in Bangladesh. The energy sector of Bangladesh largely depends on natural gas and petroleum oil. But the reserves are inadequate to meet the energy demand for long term economic growth. Biodiesel can be an alternative to these fossil fuels. Biodiesel is non-toxic and biodegradable. The combustion of Biodiesel emits very less amount of CO_X, SO_X, hydrocarbons and particulate matter. In Bangladesh, a good number of edible and non-edible Biodiesel feedstock is available. But the edible sources are not promising as they need arable lands for cultivation. The arable lands in Bangladesh are used for food production. About 47750 km of road and railway side arid lands can be used to produce non-edible Biodiesel feedstock. But Algae can be the most effective source of Biodiesel. Algae possess high productivity and high lipid content. Producing 1kg of Algae Biodiesel can fix 1.83 kg of CO_2. Algae can be produced in non-arable lands, fresh water, salt water and waste water. In Bangladesh, about 4.418 million hectares of infertile land, 1.383 million hectares of water areas (lakes, rivers, costal saline water etc.) and 0.31 million hectares of ponds are available which can be used for Algae production. Flue gases and waste water of industries also can be incorporated with Algae cultivation which may reduce the production cost. To reduce the cost as lower as Diesel, more researches are needed to select the convenient species and production procedure.

Keywords:– *Algae, Biodiesel, Biodiesel feedstock, Renewable energy, Non-edible oil*

I. INTRODUCTION

The energy sector of Bangladesh is in enormous pressure. The energy demand is increasing for its huge population growth. The energy sector excessively depends on natural gas and petroleum oil. Though Bangladesh is the twenty-eighth ranked natural gas producer country in 2014, the total amount of 23.6 billion cubic meters of produced gas is consumed domestically [1]. In 2015, natural gas proved reserve is 14.16 trillion cubic feet from 25 gas fields [2]. But the present gas reserve may run out in about a decade. Bangladesh has very low reserve of petroleum oil. At present the extractable reserve is only 55 million barrels from two abandoned gas fields of Kailashtila and Haripur [3]. In 2014, the oil production was 4200 barrels per day from its 28000 barrels refinery [4]. The government had to import 108187 barrels per day of petroleum oil to remove the imbalance of demand and supply. In 2015, Bangladesh imports total 1092673 million tons of crude oil [5].The maximum share of primary energy comes from fossil fuels. The combustion of fossil fuels increases environmental degradation. In these circumstances, the fossil fuels must be replaced by renewable sources of energy. Many alternative sources are being studied including solar, wind, water, tidal and wave, geothermal, biomass and biofuel [6-12]. Biofuel are derived from renewable sources and they have the potentiality to be an alternative to fossil fuel. The common biofuel are Ethanol and Biodiesel. Biodiesel is produced in many countries as an alternative to Diesel fuel. Fig. 1 shows the world's biggest Biodiesel producing countries according to their production volume in 2015 [13].

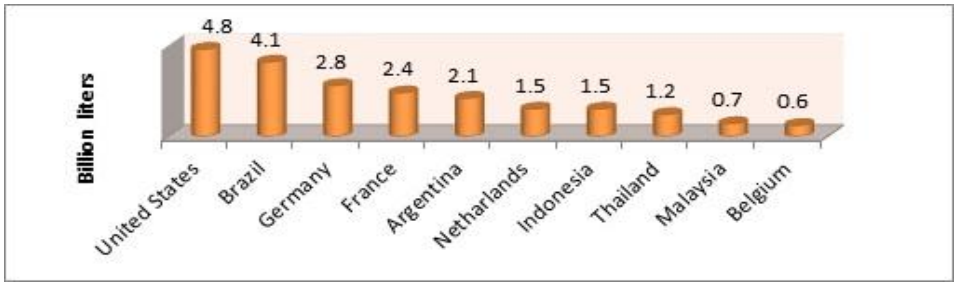

Figure 1: Biodiesel production in 2015

United States is the largest Biodiesel producer in world. In 2014, the total Biodiesel production in United States was 4.7 billion liters. In 2015, the production is 4.8 billion liters. The production comes from 94 Biodiesel plants with total capacity of 7.95 billion liters. Soybean is the largest feedstock for Biodiesel production in United States, and the other available sources are Canola oil, Corn oil, animal fats etc. Indonesia is the largest Biodiesel producer in Asia with the total production of 1.5 billion liters. Palm is the main feedstock of Biodiesel in Indonesia. Table 1 shows the dominating sources of Biodiesel production in different countries [14].

Table 1: Leading feedstock of Biodiesel

Country	**Biodiesel source**
United State	Soybean, Canola
Brazil	Soybean, Cotton seed
Europe	Rapeseed, Sunflower
Canada	Canola
Africa	Jatropha
China	Waste Cooking oil
Indonesia	Palm
Malaysia	Palm
Philippines	Coconut
Thailand	Palm, Waste Cooking oil
India	Jatropha

Biodiesel can be a promising sustainable source of energy in Bangladesh. A good number of edible and non-edible sources of Biodiesel feedstock are available in Bangladesh [15].The objective of this study is to focus on present status of Biodiesel research and resources in Bangladesh. As Biodiesel has the potentiality to be a green renewable substitute to natural gas and petroleum oil, therefore this study has a broad scope to mitigate the present energy crisis of Bangladesh.

II. BIODIESEL

Biodiesel is mainly produced from edible and non-edible vegetable oils, animal fats and waste cooking oil. Biodiesel is Monoalkyl esters of long chain Fatty acids. Vegetable oil undergoes a transesterification process to become Biodiesel. Alcohol and a catalyst are added to separate the fuel from the byproducts. Usually Methanol (alcohol) and Sodium hydroxide (catalyst) are added to the raw oil [16]. The chemical reaction (transesterification) yields Biodiesel and Glycerin. Glycerin is the heavier of the two byproducts. Glycerin sinks to the bottom of the mixing tank. It can be used for soaps and other pharmaceuticals production. Some Alcohol can be recovered and reused. Biodiesel is usually blended with Diesel. It also can be used in pure form with some modifications of engine. Biodiesel has cleaner emissions and nontoxic properties compared to Diesel. The emission of pure Biodiesel reduces 67% of unburned Hydrocarbons, 48% of Carbon monoxide, 100% of Sulfates and 75% of Carcinogenic byproducts. Only there is an increment of 10% Nitrogen oxide as a component of smog. A system known as 'B' factor is used to state the amount of Biodiesel in any fuel mixture. Fuel containing 10% of Biodiesel is leveled as B10. B100 is used for pure Biodiesel. Biodiesel can be produced from various sources such as Soybean, Mustard, Palm, Maize, Mahua, Coconut, Corn, Cotton seed, Sunflower, Olive, Jatropha, Castor, Karanja, Sesame, Neem, Rubber, Algae etc. Biodiesel sources can be broken down into three generations.

- First generation (Biodiesel produced from Soybean, Mustard, Coconut, Sesame, Mosna etc.)
- Second generation (Biodiesel produced from Jatropha, Karanj, Castor, Bahera, Rubber etc.)
- Third generation (Biodiesel produced from Algae)

Biodiesel produced from edible feedstock is considered as first generation. Arable lands are needed for cultivation of first generation Biodiesel feedstock. Second generation refers the non-edible sources of Biodiesel production. Arid and waste land can be used for second generation Biodiesel production. Biodiesel produced from Algae is considered as third generation. Biodiesel produced from Algae has some advantages over the other available sources. The growth rate is very fast for algae. Algae possess high lipid content.

III. BIODIESEL IN BANGLADESH

In Bangladesh, Biodiesel can be produced from both edible and non-edible sources of oil such as Soybean (*Glycine max*) [17, 18], Mustard **(***Brassica nigra*) [19-21], Sesame (*Sesamum indicum*) [22], Mosna, Jatropha (*Jatropha curcas*) [23-25], Castor (*Ricinus communis*) [26-28], Bahera (*T. bellirica*) [29], Neem (*Azadirachta indica*), algae [30-32] etc. Soybean cultivation in Bangladesh is limited. Bangladesh can meet only 40% of its Soybean oil demand by producing locally. But 0.7 – 0.8 million hectares of land in char areas could be brought under Soybean cultivation. About 1.7 – 1.8 million metric ton of Soybean could be produced. It can be used for human consumption as well as Biodiesel production. Mustard plants grow widely all over the

country. The production of Mustard seed exceeds the demand in every year. The surplus Mustard seed can be used as a source of Biodiesel. Sesame grows in almost all over the country. Sesame contains 42.5% - 46.2% oil [33]. Mosna is one of the edible oil plants that are mainly cultivated in the southern part of Bangladesh. The production of Mosna needs less fertile land. The cultivation of Mosna is cheaper than other vegetable oil plants. Jatropha is a non-edible plant. It grows in arable and arid lands. It contains 30% - 40% oil. Jatropha can be cultivated in the southern part of Bangladesh. Castor grows almost everywhere in Bangladesh. It can grow in stony, sandy and saline lands. Castor seeds contain 67.7% oil [33]. Castor plant can live for many years. It can produce huge amount of seeds every year. Bahera is found in large proportion in Bangladesh. It is commonly used as a medicinal plant. It can be cultivated almost all over the country though preferable in tropical and subtropical areas. Bahera fruits contain about 30% oil by mass of crushed Kernel. Neem is a non-edible plant. It grows everywhere in Bangladesh. Neem seeds contain 45% oil. The climate of Bangladesh is suitable for algae production. Algae can grow rapidly in fresh water, saline water, waste water and arid lands. The number of species of Algae varies from 30,000 to over 1 million. Some of them contain up to 80% oil of their dry weight. Algae possess fast growth rate and high productivity. The fuel properties of various Biodiesel feedstocks have been studied by the researchers of Bangladesh. Table 2 shows the fuel properties of some of the Biodiesel feedstock oil [17-32].

Table 2: Fuel properties of Biodiesel from different feedstock

Fuel	**Specific gravity at 15°C**	**Kinematic viscosity (mm^2/s) at 40°C**	**Moisture content (%)**	**Calorific value MJ/kg**	**Cetane number**	**Flash point (°C)**	**Fire point (°C)**	**Cloud point (°C)**	**Pour point (°C)**
Diesel	0.85	2.98	0.05	43.4	47	72	210	-15 to 5	-35 to -15
Biodiesel standard	0.88	1.9 to 6.0	0.05 max.	37.5	48 to 60	100 to 170		-3 to 12	-15 to 10
Soybean	0.928	5.4	0.05	38.2	37.9	135	342	-3	-6
Mustard	0.938	7.28	0.005	39.51	53	156	343	3.2	-4
Sesame	0.922	36.0	---	43.54	41.8	170	---	-6	---
Mosna	0.903	25.24	---	46.39	---	---	---	---	---
Jatropha	0.87	4.59	0.005	39.5	43	182	190	2.7	2
Castor	0.9628	15.98	---	36.25	55.9	183	335	3	2
Bahera	0.9077	5.936	0.07	---	53.4	162	---	5	1
Neem	0.968	50.3	0.005	39.81	31	76	---	9	2
Algae	0.864	4.519	0.005	41	48 to 65	75	81	-5.9 to 3.9	-12

Some Biodiesel feedstocks have the better calorific value and Cetane number. Mosna oil has the calorific value of 46.39 MJ/kg. The Cetane number of Mustard oil, Castor oil and Bahera oil is 53, 55.9 and 53.4 respectively. The properties of Algae Biodiesel are comparable to the properties of Diesel. Some other sources of Biodiesel are also available in Bangladesh such as Karanj (*Pongamiapinnata*) [34, 35]**,** Cottonseed (*Gossypiumhirsutum*), Coconut (*Cocosnucifera*) [36], Rubber (*Heveabarasiliensis*) etc. The cultivation of Karanja plant in unused land of Bangladesh can reduce imported petroleum oil by 28%. Oil content of Karanja is 31.8% [37]. Cotton is mainly grown as rain fed crop in Bangladesh. It is generally cultivated in south western region, northern region, central region and hilly areas. An experiment showed 77% Biodiesel production from Cottonseed oil with 20% Methanol in presence of 0.5% Sodium hydroxide. Coconut is widely growing tree in Bangladesh. In the southern part of the country, coconut is considered as natural asset. Biodiesel can be produced from Coconut. Oil content of Coconut is comparatively higher than Soybean and Mustard. Coconut oil has better lubricant property. Rubber seed oil is a non-edible feedstock for Biodiesel production. Bangladesh has huge potentiality to grow Rubber seed. Rubber seeds contain 49% oil. Rice bran oil can be a potential Biodiesel feedstock in Bangladesh. Rice bran is a by-product of rice mill that contains 15-23% lipids [38].A local plant named Jamalgota (*Corton Tiglium*) can be the Biodiesel feedstock with oil content of 32-40% of the weight of dried seeds. Biodiesel also can be produced from mixed feedstock oil. In an experiment, mixed feedstock oil is prepared by random mixing of Bakul oil, Waste Cooking oil, Nahor oil, Pitraj oil, Karanja oil and Castor oil [39]. Table 3 shows the properties of the mixed feedstock oil Biodiesel [39].

Table 3: Fuel properties of mixed feedstock oil Biodiesel

Fuel	**Specific gravity**	**Kinematic viscosity (mm^2/s) at 40°**	**Moisture content (%)**	**Flash point (°C)**	**Cloud point (°C)**	**Pour point (°C)**
Mixed feedstock Biodiesel	0.82 at 25°C	3.96	0.05	155	3	0
Biodiesel standard	0.88 at 15.5°C	1.9 to 6.0	0.05 max.	100 to 170	-3 to 12	-15 to 10
Diesel	0.85 at 15°C	2.98	0.05	72	-15 to 5	-35 to -15

The oil composition is 33% Waste Cooking oil, 25% Pitraj oil, 25% Castor oil, 7% Bakul oil, 5% Nahor oil, 5% Karanja oil. Oils are collected from the local sources of Sylhet city in Bangladesh.

IV. DISCUSSION

For Diesel engines Biodiesel gives almost the similar energy performance compared to Diesel [40]. The edible sources of Biodiesel can assure the energy security. They also can decrease the environmental degradation. The production of Biodiesel from edible sources needs arable agricultural lands. But the arable lands of Bangladesh cannot be used for Biodiesel production. Due to the food demand for huge population it may influence on food security. The non-edible sources of Biodiesel have the advantage of not affecting the human food chain. The non-edible Biodiesel plants can be grown in marginal and waste lands. Non-arable lands of railway and road sides can be used for Biodiesel production. After surveying lands for this purpose it seems that Bangladesh can get a total amount of 47750 km of road and railway side areas for the cultivation of non-edible Biodiesel feedstock [41]. Biodiesel produced from Algae is considered as the third generation of Biodiesel source. Biodiesel produced from Algae can overcome the limitations of the first and the second generation. Algae can grow in non-arable lands, fresh water, saline water and waste water. At present there are 0.73 million hectares of dry land, 3.16 million hectares of low marshy land and 0.218 million hectares of coastal saline land are available in Bangladesh. These lands are not suitable for production of food crops. These large areas can be used for Algae production. About 1.383 million hectares of water area including rivers, lakes and costal saline water can be used for algae production. Algae also can be produced in 0.31 million hectares of available ponds in Bangladesh. But the most challenging part of Algae Biodiesel is to reduce the price as lower as Diesel. The production cost of Biodiesel fluctuates significantly for different feedstock. Biodiesel is generally reported as being more costly than conventional Diesel fuel. Some measures can be taken to minimize the cost of Algae cultivation. The production of Algae needs CO_2. It can be incorporated with the power plant flue gas. It will minimize the cost of the Algae production and also will reduce air pollution. Water required for Algae production can be used from any source. Bangladesh has huge natural water resources. Even the wastewater from industries can be used for Algae production. Waste water contains Nitrogen or Phosphorus which are nutrients for Algae. It can minimize the production cost. It also can mitigate the environment pollution. Adequate light is another requirement for high rate of Algae production. Throughout the year, except some cloudy days in rainy season, sunlight is sufficient in Bangladesh for Algae production. Algae have more than one million species. The growth rate and the oil content are not same for all species. More researches are required to seek out the convenient species of Algae for environment of Bangladesh. More researches need to be carried out for establishing Algae Biodiesel as a substitute to Diesel by minimizing the production cost.

V. CONCLUSION

The geography of Bangladesh is favorable for Biodiesel production. Some non-edible sources of Biodiesel feedstock such as Jatropha, Castor, Bahera, Neem, Karanja, Cotton seed, Rubber etc. can be the suitable candidates. But Biodiesel produced from Algae can be the most promising source. In Bangladesh, about 6.1 million hectares of infertile lands and water area can be used for Algae production. But the production cost must be reduced to establish it as a sustainable substitute to Diesel. More researches need to be carried out to select the convenient species of Algae and to establish the most economical production method.

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