Extraction of Bio-Fuel from a Second Generation Energy Crop (Pennisetum Purpureum K. Schumach) and Its Future Prospects in Bangladesh

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***Abstract*—Second generation bio-fuels are extracted from lignocellulosic biomass. This process uses low cost, non-edible feedstock. One such potential candidate for this process is pennisetum purpureum k. schumach, also known as elephant grass. Its specialty is that it can grow on a land regardless of the soil type and fertility, i.e. it can be grown on lands which are not used for agricultural purposes and especially where the soil contains high percentage of Nacl or has a pH level of 4.5 to 8.2. This paper investigates the prospects of pennisetum purpureum k. schumach as a bio-fuel and using it an alternate source of energy and analyzes the percentage of extracted bio-fuel in lab condition by using rotary evaporator.**

***Index Terms*—Second generation bio-fuels, extraction process, environmental benefit, future prospects, rotary evaporator**

I. Introduction

Recent increases in the production of crop-based (or, first generation) bio-fuels have brought forth the tradeoff between efficient use of lands in food crop production and a means to generate energy which will result in reduction of the emission of greenhouse gases during the power generation process. Attempts to avoid this stalemate have prompted the development of bio-fuels produced from non-food biomass (second-generation bio-fuels). Its efficiency can be understood by discussing the environmental benefits of using such a form of energy and various industrial usages of the byproducts obtained during this process.

The Energy availability shapes the fates of a civilization. At present, the world is facing acute problems due to crisis of energy and environmental deterioration, the reason behind in the direct relationship of environment and energy. The use of fossil fuels as a source of energy is regarded as unsustainable in today's world because of its adverse effects on the environment. The scenario in Bangladesh has turned into more destructive shape because now only about 32% of the population has access to electricity and this figure worsens in the rural areas to 22%; electricity mainly come from the usage of fossil fuels but fossil energy storage is limited, and it will be more depleted in near future [1]. For the production of electricity and running industries, Bangladesh's crude oil consumption has increased radically. The country has to import 3.5-4.0 million tons of petroleum and related products per year. In 2011, the amount of money spent on such imports was about $ 5 million which is 10% more in contrast to the year 2000 [1].

Taking the trend of economic growth into account, Bangladesh's strong dependence on foreign oil cannot be mitigated in the future without developing self-dependent sustainable alternatives like renewable energy. Many of the problems associated with 1st generation bio-fuels can be addressed by the production of bio-fuels manufactured from agricultural and forest residues and from non-food crop feedstock where the lingo-cellulosic feedstock is to be produced from specialist energy crops grown on arable land. Several concerns remain over competing land use, although energy yields (in terms of GJ/ha (Giga joule per hectare)) are likely to be higher than if crops grown for 1st-generation bio-fuels (and co-products) are produced on the same land. In addition poorer quality land could possibly be utilized. For all these reason, second generation bio-fuel such as pennisetum purpureum k. schumach is perfectly suitable for Bangladesh as well as different countries in Asia, Africa and some other countries in America as it can be grown in low fertile land.

II. Characteristics and Conditions for Growth

A rich soil is most suitable to get the best harvest of Elephant grass. The capability of this kind of grass to tolerate frost is quite low. The herbage cannot withstand frost; however, the rhizome dies only when the soil freezes up. Although a best production may require rich and well-drained soil, this grass is capable of a decent growth on poorly drained or, dry sandy soils as well. Table I shows this type of grass can survive warm dry temperature and also wet tropical weather as the lifespan of this grass is elongated [2].

TABLE I: Morphological Characteristics of Elephant Grass.

Activate Growth Period	Summer and Fall
C:N Ratio	Medium
Flower Conspicuous	No
Foliage Color	Green
Fruit/Seed Color	Brown
Growth Rate	Rapid
Lifespan	Long

Elephant grass is reported to tolerate annual precipitation of 2.0 to 40.0 dm, an annual temperature of 13.6 to 27.3 ℃ and a pH level of 4.5 to 8.2(Duke1978,1979) [3].

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TABLE II: GROWTH REQUIREMENTS OF ELEPHANT GRASS [4]

$CaCO_3$ Tolerance	None
Fertility Requirement	Medium
Planting Density per Acre, Minimum	1700
Planting Density per Acre, Maximum	4800
Root Depth, Minimum(inches)	14
Precipitation, Maximum(mL)	100

Tall, rhizomatous perennial very coarse and robust, in dense clumps; culms 2-7 m tall; leaves large, 30-90 cm long, up to 3 cm broad, elongate; panicles dense, usually more than 15 cm long, stiff, tawny or purplish; fascicles sessile, the sparsely plumose bristles exceeding the 2 or 3 unequally pedicelled spikelet's; grain permanently enclosed in the lemma and palea; spikelet's not more than 7 mm long [5]. It is grown in rows and cultivated for highest yields. Fertilizer of 100-150 kg/ha (kilograme/hectare) of N after each harvest gives best uniform production, with total of 900 kg/ha of N for six harvests [5]. Potential carrying capacity of Elephant grass is very high with the application of 50 kg/ha of N after each harvest, thus maintaining about 27 head/ha. Feeding whole or chopped at 45 day re-growth had no effect on digestibility of all nutrients, but wilting increased the digestibility of dry matter, crude protein and crude fiber; also digestibility of N-free extract and gross energy were significantly higher for wilted than for fresh grass [6]. These factors were increased in 60 day re-growth. Pennisetum purpurem k. schumach is one of the highest yielding tropical forage grasses. According to the Table II, it shows that the minimum and the maximum planting density per acre of elephant is 1700 and 4800.Its steamy nature limits its usefulness for grazing purposes, as animals selectively eats leafy portions and leave steams behind. Some condition for growth of pennisetum purpureum k. schumach is given below:

III. METHODS AND MATERIALS

For the experiment of extraction in lab condition, Fig. 1 shows approximately 1kg of pennisetum purpureum k. schumach is collected; the stocks and leaves of the obtained grass were blended with water to get the extract.300ml of green grass extract liquid was acquired from the blended grass sample which is shown in Fig. 2. It is to be mentioned that this obtained extract was highly diluted as only household blender with low efficiency was used for the extraction process which failed to produce significant amount of grass juice when blended without water. Fig. 3 shows this green liquid was put into Rotary Evaporator and the alcohol part, in this case ethanol, was removed. Two separate readings were taken under different conditions. At first, the rotary evaporator machine was set at 55 ℃ and 270 mbar pressures and 16 ml of colorless liquid was obtained from the green extract by the process of evaporation. The next reading was taken at 60 ℃ and 275 mbar and another 10ml of extract was obtained which is shown in Fig. 4. When the pressure above a bulk liquid is lowered; the component liquids experience a reduced boiling point. This is the main principle of the rotary evaporator. So, this machine allows the removal of liquid solvents from a solution without heating it excessively. This is necessary because sometimes complex and sensitive solvent-solution combination forms due to overheating. Again, due to the centrifugal force and frictional force between the wall of the rotating flask and the liquid solution, a thin film of warm solvent spread over a large surface very quickly. Generally, the boiling point of ethanol is 78 ℃ at normal temperature and pressure; however, here evaporations were possible at 55 ℃ and 60 ℃ due to the reduced pressure. The obtained colorless liquids through rotary evaporation process were tested for ethanol. Fig. 5 shows the Conway method was used for the identification and estimation of ethanol in the liquid.

Fig. 1. Pennisetum purpurem K. Schumach, or elephant grass

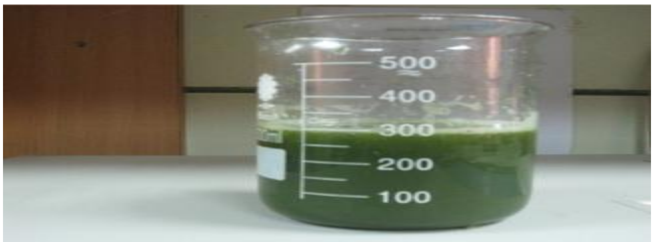

Fig. 2. Extracted green liquid from Elephant grass

Fig. 3. Extraction of colorless liquid from green extract using Rotary Evaporator

IV. THEORY AND RESULTS

The process which we used here is very unique. In this process, Ethanol is determined by Redox titration. Ethanol is first oxidized to ethanoic acid by reacting with excess potassium dichromate solution (0.05 N). The dichromates which do not react in the previous step are determined by adding potassium iodide (50% KI) solution which is oxidized by the potassium dichromate. Potassium iodide reacts with potassium dichromate and iodine. Then the iodine is treated with a standard solution of sodium thiosulphate (0.1 N). The ethanol content after fermentation is calculated from the titration reading. One ml Fermented solution was diluted up to 250 ml; 500 ml and 1000 ml distilled water and took one ml diluted solution as sample. A Conway unit is used for ethanol determination by this procedure. One ml potassium dichromate was placed into the Conway unit center and sample was placed around the centre. The Conway unit was then covered by a glass plate for 24 hours for reaction.

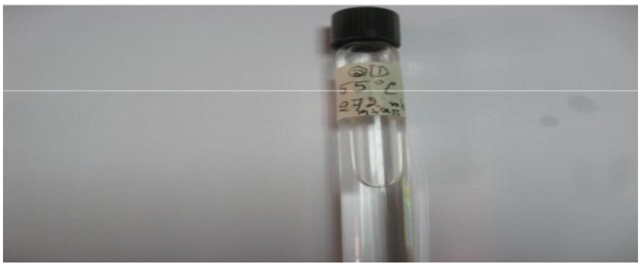

Fig. 4. Sample used for Conway Method.

The water and ethanol slowly evaporates then come in contact with Potassium dichromate and then is oxidized. More ethanol evaporates until eventually all the ethanol from the fermented dilute solution had left the sample and reacted with dichromate. One Conway unit was used as a blank, and in that unit 1 ml distilled water was used as a sample. Flowchart of micro diffusion analysis and volumetric error are given below:

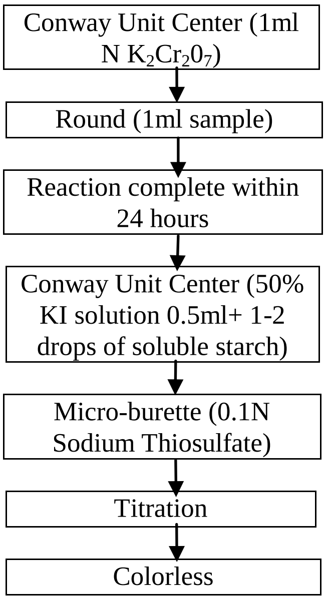

Table III shows three samples which we took to determine the quantity of alcohol in the pennisetum purpureum k schumach. The result of the percentage of ethanol is given below:

TABLE III: IDENTIFICATION AND ESTIMATION OF ETHANOL USING CONWAY METHOD

Sample No.	Initial Reading (ml)	Final Reading (ml)	Titration Reading (ml)	Percentage of-ethanol (%)
1.	0	0.5	0.5	10.93
2.	0.8	0.10	0.2	12.24
3.	.11	0.13	0.2	12.24

V. CALCULATION

DF – Dilution Factor
FS – Fermented solution
TR – Titration Reading

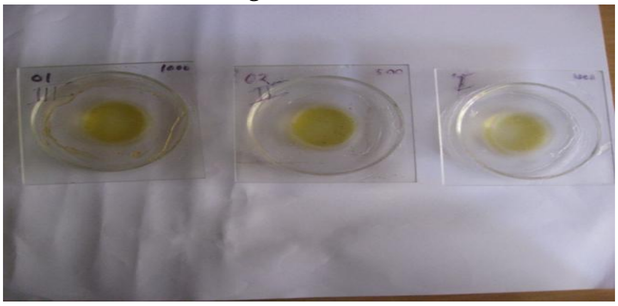

Fig. 5. Identification and estimation of Ethanol using Conway method

The equation of determining the alcohol is given below:

Percentage of Ethanol = ((TR of blank sample – TR of FS) ×11.5 ×0.1 ×DF ×100)/ (0.793 ×1000) gm/100ml

Where, Density of Ethano =l 0.793 g/ml
Volume of sodium thiosulphate used= 11.60 cm3
Titration reading of blank= .30
Dilution factor was taken to be 299

For no.1 sample,
Percentage of Ethanol = ((.30 – .05) × 11.5 × 0.1 × 299 ×100)/ (0.793 ×1000)= 10.93 gm/100ml

For no.2 & 3 samples,
Percentage of Ethanol = ((.30 – .02) × 11.5 × 0.1 × 299 ×100)/ (0.793 ×1000)= 12.24 gm/100ml

Fig. 6 was drawn on the basis of the quantity of sample used for convey method Vs the percentage of ethanol it contains.

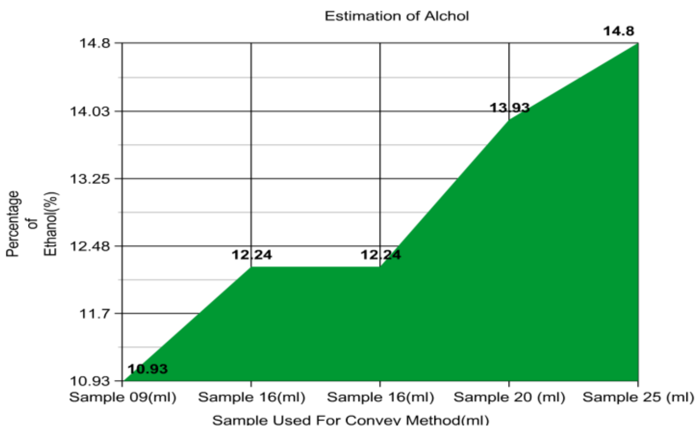

Fig. 6. Estimation of Alcohol

VI. Conclusion

This experiment result shows that ethanol can be found in Elephant grass which can further be used for different purpose such as generating power or fuel of the vehicle. This paper emphasizes the convey method rather than other traditional method for extracting the alcohol from pennisetum purpureum k. schumach. This process is quite easier and can be easily achieved. The extract was collected by using household blender; the collected sample had low efficiency and did not match the expected result. With use of gascromotograph in the extraction process a better result along with the significant outcome can be achieved. Therefore it can be said that, as the availability of pennisetum purpurem k. schumach is easier in Bangladesh as well as other parts of the world so this experiment can turn into a great attainment if it is underdone by industrialization process. The future prospect of pennisetum purpureum k. schumach in Bangladesh is reasonable as it is easily available all around the country. Renewable energy supplies only 5% in the total energy in Bangladesh which indicates that Bangladesh mainly depends on fossil fuels but the fossil fuel are very close to extinct [7]. So, the only way to sustain the progress on economic and environmental field is to give emphasizes on the uses of renewable energy especially the biofuel from second generation crops such as pennisetum purpureum k. schumach.

Second-generation bio-fuel could avoid many of the problems facing in the first-generation biofuels and can offer greater cost reduction potential in the longer term. Economically, lignocellulosic biomass has an advantage over other agriculturally important biofuels feedstocks such as Elephant grass, because it can be produced quickly and at a significantly lower cost than food crops. Biofuels from second generation are gaining increased public and scientific attention driven by factors such as oil price hikes, the need for increased energy security, and concern over greenhouse gas emissions from fossil fuels along with support from government subsides. By taking proper steps, biofuel from Elephant grass can be turned into great success and can be replaced to fossil fuel.

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References

[1] M. A. Alam, "Renewable energy for sustainable Bangladesh (part-01)," *Energy& Environment*.

[2] J. A. Duke, "The quest for tolerant germplasm," in *ASA Special Symposium 32, Crop tolerance to suboptimal land conditions*, Am. Soc. Agron. Madison, WI, pp. 1–61, 1978.

[3] J. A. Duke, "Ecosystematic data on economic plants. Quart," *J. Crude Drug Res*, 1979, vol. 17, no. 3–4, pp. 91–110

[4] *Conservation Plant Characteristics, pennisetum purpureum k.schumach, Elephant-grass, PEPU2,* Natural-Resources Conservation Services, United States Department of Agriculture.

[5] J. A. Duke, *Handbook of Energy Crops*, unpublished, 1983.

[6] B. Venkatesh and H. P. C. Shetty, "Studies on the growth rate of the grass carp (Ctenopharyngodon idella Valenciennes) fed on two aquatic weeds and a terrestrial grass," *Aquaculture*, 1978, vol. 13, no. 1, pp. 45–53.

[7] N. Chowdhury, S. Reza, T. Nitol, and Mahabub, "A Present Scenario of Renewable Energy in Bangladesh and a Proposed Hybrid System to Minimize Power Crisis in Remote Areas," *International Journal of Renewable Energy Research.* vol. 2, no. 2, 2012.

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