

## Impact of biofuel utilization in engine fuel: an ecofriendly product

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**Abstract :** Biofuel initiative has been backed by government policies in the quest for energy security through partially replacing the limited fossil fuels and reducing threat to the environment from exhaust emissions and global warming. The main fuel found to be an increasingly important alternative to petroleum is bio-fuel. It is biodegradable, and produces significantly less air pollution than fossil fuel. In a large excess Biofuels (Bioethanol, Biodiesel) are produced by agroresidues and from algal biomass. Agro residues are the main source of lignocellulosic biomass. Lignocellulosic materials composed of cellulose, hemicelluloses and lignin, are the world's most widely available low-cost renewable resources to be considered for ethanol production. Sugarcane bagasse, rice hulls, wheat straw, rape straw, wheat bran, barley straw and cassava stalks are agricultural and agro-industrial residues that could be considered for bioconversion. Bioethanol is an attractive, sustainable energy source to fuel transportation, which is prepared by these agro residues in different steps. Pretreatment is the first step to degrade the biomass component. There are different types of methods of pretreatment one of which dilute acid pretreatment. After pretreatment enzymatic hydrolysis is used to ferment pre-treated biomass either by using simultaneous saccharification or by further acid treatment. Simultaneous saccharification and fermentation (SSF) process is favoured for producing ethanol from the major fraction of lignocellulosic biomass, cellulose, because of its low cost potential.

An attempt has been made in this paper to use alternative fuel in four stroke Gasoline engine. As a gaseous fuel, gains from LPG have already been established in terms of low emissions of carbon monoxide, hydrocarbon. Ethanol is one of the fuel additive has some advantages such as better antiknock characteristics and the reduction of CO and HC emissions. It can be considered as renewable energy under the environmental consideration. The purpose of this study is to investigate experimentally and compare the engine performance and pollutant emission of a SI engine using ethanol-gasoline blended fuel and pure gasoline. The results showed that when ethanol is added, the heating value of the blended fuel decreases, while the octane number of the blended fuel increases. The results of the engine test indicated that when ethanol-gasoline blended fuel is used, the engine power and specific fuel consumption of the engine slightly increase; CO emission decreases dramatically as a result of the leaning effect caused by the ethanol addition; HC emission decreases in some engine working conditions; and CO<sub>2</sub> emission increases because of the improved combustion.

**Keywords:** Agro residues, Biomass, Ethanol, Pretreatment, Hydrolysis, Octane number, Emission.

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### I. INTRODUCTION

Climate change due to global warming and with an increasing demand for energy, volatile oil prices, and energy poverty have led to a search for alternative sources of energy which would be economically efficient, socially equitable, and environmentally sound. One of such type of fuel is biofuels. It provides substantial energy and mitigating climate change so that both government and industry owners in many countries encourage increasing the production of biofuels. Ethanol is a liquid biofuel produced from sugar rich biomass. The production of ethanol has gained importance in last few years due to the increased dependency on oil and conventional fuels. Ethanol can be blended up to 20 per cent with diesel or petrol [1]. At present ethanol is produced from molasses, which is by product of sugar industries. The cost of production increases as the demand for molasses has increased. Hence, it is absolutely necessary to search for alternate source for ethanol production. So far, common crops recognized are sugarcane, sweet sorghum, beet and potato. The agricultural crop residues such as rape straw, rice straw, wheat straw and bagasse are abundantly available having rich source of sugars. The low cost and renewable nature of agro-residues such as sugarcane bagasse, wheat straw, rice straw, corn stover, etc. represent the ideal feedstock for their conversion into value-added products by biotechnological routes [2]. These agro-residues, like other lignocellulosic materials, are constituted primarily of lignin, hemicelluloses and cellulose. The carbohydrate fraction (hemicellulose and cellulose) can be depolymerised into sugars which act as a primary carbon source for the microbial biocatalysts for the production of xylitol, ethanol, organic acids, industrial enzymes, etc. [2, 3 & 4].

**Ethanol:** Ethanol (C<sub>2</sub>H<sub>5</sub>OH) is a renewable fuel. It can be produced from agricultural feedstocks, such as sugarcane and also from forestry wood wastes and agricultural residues. It can also be derived chemically from ethylene or ethane. Ethanol has a simple molecular structure with well-defined physical and chemical properties.

Ethanol can be employed as a transportation fuel even in its original form and can also be easily blended with other fuels, such as gasoline and diesel. Ethanol contains no sulphur, olefins, benzene and other aromatics. All of which are component of gasoline that can affect air quality and threaten human health [5]. Benzene is carcinogen, while olefins and some other aromatics are precursor to ground-level Ozone (smog). Ethanol-gasoline blends also reduce toxic emissions of 1,3-butadiene, toluene, xylene, while few studies have a looked at the impacts on the pollution levels from high blends. With ethanol fuel combustion, emission of the toxic air pollutants acetaldehyde, formaldehyde, peroxyacetyl nitrate (PAN) increase relative to straight gasoline [6]. Most is emitted as acetaldehyde, a less reactive and less toxic pollutant than formaldehyde. Neither pollutant present in fuel; they are created as by product of incomplete combustion. PAN is an eye irritant that is harmful to plants, is also formed as by product [6].

Ethanol is an effective solvent and can be considered a fuel detergent. On one hand, this can help remove gum and deposits from fuel systems and is the reason alcohol is often used as a gasoline additive. A potential drawback for old, small engines is that neglected fuel systems may begin to precipitate old deposits at a greater rate than normal and clog fuel filters and small passageways. This is the suspected main reason for many ethanol related engine complaints. It should be pointed out that deposits in fuel tanks and carburettor bowls will eventually cause problems in engines running straight gasoline; however ethanol blends may accelerate the release of deposits. Old fuel systems should be periodically inspected regardless of fuel type. Ethanol has hygroscopic qualities in it that attracts and mixes with water. At lower concentrations of water (up to 0.5 percent volume at 60° F), the alcohol will mix and remove the water as the fuel is burned and not harm the engine. At higher concentrations, the water will separate from the fuel and pool at the bottom of its container. This “phase” separation form of water in fuel can cause rust and possibly damage the engine. Fuel that is an E10 blend cannot absorb enough moisture out of the air to cause this phase separation [7]. However, if condensation is allowed to occur, or water is directly splashed in the tank, water phase separation can occur. It should be pointed out that this water separation is more likely to occur in straight gasoline than in an ethanol blend.

**Biodiesel:** Biodiesel – whether pure or blended- results in lower emissions of most pollutants relative to diesel, including significantly lower emission of particulates, sulphur, hydrocarbons, CO, toxins [8]. Emissions vary with engine design, condition of vehicles and quality of fuel. In biodiesel- diesel blends, potential reductions of most pollutants increase almost linearly as the share of biodiesel increases, with the exception of NO<sub>x</sub> emission [6]. In general, the air quality benefits of biofuel are greater in developing countries, where vehicle emission standards are non-existent or less stringent and where older more polluting cars are more common [9]. For example, the use of ethanol can effectively reduce emissions from CO and hydrocarbons in old technology vehicle today. Less understood, however, are the impacts that biodiesel might have on exhaust emission from vehicles that are underpowered, over-fuelled, overloaded and not well maintained- vehicles that are most prevalent in the world’s developing nation [5].

Biodiesel is nontoxic and biodegradable when introduced in neat form [10, 11], and it is an oxygenated fuel which contributes to a more complete fuel burn. Their cetane numbers is higher than those of vegetable oil and diesel fuel and hence produce less THC emission [12, 13 &14]. Biodiesel does not contain any aromatic components, and with low sulphur content produces low exhaust PM emissions, sulphur dioxide and lower aromatic HC emissions [15, 16]. Many researchers have been developed on biodiesel and its characteristics. The behaviour of biodiesel in internal combustion engines is well documented in the literature [16]. Engine performance is slightly lower when using biodiesel because of its lower heating value with respect to that of diesel fuel; if the injection phase is done well, engine efficiency doesn’t significantly change. Reduction in regulated emissions has been reported as well: pure biodiesel shows an average reduction of 50% for CO, 65% for total unburned hydrocarbons (HC), 50% for particulate matter (PM). NO<sub>x</sub> emissions, on the contrary, are 10% higher; for biodiesel–diesel blends’ reductions vary almost proportionally with the concentration of biodiesel in the blend. The most promising blend is the mixture of 20% biodiesel 80% diesel fuel, commonly known as B20 blend.

**Properties of Fuels that Affect the Performance of IC Engine:** The fuel used in an internal combustion engine which strongly affected efficiency as well as power. If an engine is more efficient, then it will produce more power, but the reverse is not necessarily true. There are many different characteristics of a fuel that determine how well the fuel will perform in an internal combustion engine. These qualities need to be considered in parallel in order to truly understand the net effect of a fuel’s usage in an engine. The heating value (qc) is defined as the heat transferred out of a system during combustion when the initial and final states of the products and reactants are at the same temperature [17]. In other words, the heating value indicates how much energy is contained in a fuel. Increasing the heating value of a fuel will increase the power output of an engine [18]. The octane number of a fuel is a measure of the tendency of the air-fuel mixture to resist self-ignition. This pre-ignition, or knock, decreases engine efficiency and increases engine wear. If a fuel has a higher octane number, then it can endure a higher compression ratio before exploding. Although the octane number by itself does not imply better engine performance, engines with higher compression ratios are more powerful and

efficient, and they need to run on fuels with high octane numbers [19]. The heat of vaporization of a fuel indicates how much heat is required to cause the fuel to change phases from a liquid to a gas. During the suction stroke, the fuel evaporates to make an air-fuel mixture (in petrol engine system). Fuels with high heat of vaporization remove more energy, or heat, from the surrounding air while evaporating, effectively lowering the temperature of the resulting air-fuel mixture. This allows more air and fuel to enter the cylinder, and increases volumetric efficiency and power output [20, 21]. Ethanol may be used as a fuel itself or in blends with petrol or diesel. It has a lower energy density than petrol or diesel, a higher octane number than petrol, and a much lower cetane number than diesel. It is highly miscible with petrol but not miscible with diesel. Ethanol-diesel blends use cetane enhancers and solubility improvers. Table 1 list the important fuel properties of ethanol and compares these with petrol and diesel fuel.

Property	Ethanol	Petrol	Diesel
Composition, weight %			
C	52.2	85-88	84-87
H	13.1	12-15	13-16
O	34.7	0	0
Density, kg/m <sup>3</sup>	794	750	825
Lower heating value, MJ/kg	26.7	42.9	43
Octane number	100	85-90	-
Cetane number / n-Heptane	8	5-15	30-40
Rapid vapour pressure (kPa)	15.6	55-103	1.4
Stoichiometric air/fuel ratio, weight	9:1	14:1	16:1
Boiling temperature, °C	78	80-225	188-343
Flash point, closed cup, °C	13	-42	74

Sources: JEC, 2005; Joseph, 2007

**Table 1:** Fuel properties of anhydrous ethanol and comparison with petrol and diesel fuel

**Current Status and Production of biofuel:** The lignocellulosic agro residues mainly comprise of cellulose, hemicellulose and lignin [22]. The carbohydrate portion of the agro residues is approximately 60% by weight and is considered as a feedstock for conversion to sugars, which may be fermented to ethanol [23]. In lignocellulose, the cellulose and hemicellulose are intimately associated with lignin [24, 25]. The lignin component acts as a physical barrier [20] and must be removed to make the carbohydrates available for further transformation. Thus, to utilize lignocellulose, it must be first pretreated to increase the surface area, bulk density and decrease the crystallinity of the cellulose, so as" to make it accessible for hydrolysis [26,27,28,29, 30 ,31 & 32]. The pretreated lignocellulose, with free cellulose, is susceptible to enzymatic hydrolysis [33]. Biomass conversion processes through enzymatic hydrolysis of pretreated lignocellulosics yield mono- and oligomeric sugar solutions, which can further be converted into fuels or chemicals, ethanol being one of them [34]. Structural parameters are also influenced the lignocellulose hydrolysis. The non-uniform distribution of lignin in lignocellulosic residue brings about physical barrier to homogeneous reactions. Another problem arises from the polar nature of lignin due to phenolic and alcoholic hydroxyl groups resulting in the formation of intermolecular hydrogen bonds [28, 29]. Enzymatic hydrolysis of native cellulose is difficult and slow. Hence, specific pretreatment processes are necessary in order to enhance the enzymatic susceptibility. Untreated lignocellulose is slowly degraded by microorganisms due to its compact and stringent structure of (1, 4) linkages in the cellulose and due to the close association of lignin with cellulose and hemicellulose, leaving very few reactive sites for enzyme attachment [3].

In India, biomass fuels dominate the rural energy consumption patterns, accounting for over 80% of total energy consumed. Fuel wood, crop residues (including plantation crops) and livestock dung are the biomass fuels used in rural areas. Fuel wood is the preferred and most dominant biomass source accounting for 54% of biofuels used in India [35]. Scarcity and increasing prices of fuel wood have been altering the biofuel consumption pattern. Due to scarcity of fuel wood, people are shifting to dung and various crop residues. The use of biofuels in domestic devices is associated with drudgery and adverse health impacts on women [36]. The farmers of the poorer countries seek for additional income and production of biomass provides them extra benefit. But it has negative implications of growing biomass for biofuel production. Current biofuels are often made from feedstock crops which also serve as food. Therefore, there is a competition between food and fuel. To produce biofuels, production of food is decreasing and many people are starving due to shortage of food, so that people of poorer countries are suffering from malnutrition and prices of foods are increasing in these countries. The most common first-generation biofuels are bioethanol, biodiesel, and biogas (CH<sub>4</sub> and other hydrocarbons). Biodiesel are obtained from edible oil or from animal oils which are transformed by a chemical process called transesterification. Second-generation biofuels can be produced from a variety of non-food sources such as waste biomass, residues, non-food cellulosic (wood) and ligno-cellulosic material (freeing the sugar molecules from cellulose using enzymes), corn stover, the stalks of wheat, and special energy or biomass

crops. Second-generation biofuels use biomass to liquid technology, by thermo chemical conversion (mainly to produce biodiesel) or fermentation (to produce cellulosic ethanol). Algae fuel (oilgae) is a biofuel from algae and denoted as a third-generation biofuel. Algae are feedstocks from aquatic cultivation for production of triglycerides to produce biodiesel. The processing technology is basically the same as for biodiesel from second-generation feedstocks. Other third-generation biofuels include alcohols like bio-propanol or bio-butanol but because of production difficulties these will not be marketed before 2050, (IEA 2008). Second and third generation biofuels are also called advanced biofuels.

## II. MATERIAL AND METHODS

Lignocellulosic dry samples such as (Sugarcane baggase, wheat straw, rape straw etc.) were taken from agricultural rural areas. All the biomass samples were dried in to oven and cut in to small pieces by milling. The method of producing ethanol from lignocelluloses involves reducing the size of biomass to smaller particles prior and using acid or enzyme treatments to hydrolyze the biomass to sugars.

**Pretreatment:** To make nonnumeric sugar utilization from these residues various physical, chemical and biological pre-treatments methods is necessary. Pretreatment is the pre step to release the components of lignocellulosic biomass. 2-3% acid ( $H_2SO_4$ ) was used for the pretreatment method. In this content acid soaked biomass slurry was autoclaved at  $121^{\circ}C$  for 30 minutes. To separate the solid and liquid fraction centrifuge method was used. The dilution and pH was maintained at 5 by adding alkali of centrifuged biomass before fermentation process.

**Microorganisms and Culture Media:** Yeast was cultured on PDA slants. Liquid medium for the preparation of the yeast was composed of 50 grams glucose, 5 grams yeast extract, 1 gram  $KH_2PO_4$ , 0.3 grams  $NH_4Cl$  and 2 grams  $MgSO_4 \cdot 7H_2O$  per litre. After inoculation of the yeast from slant in this environment, it was placed in shaker at  $41^{\circ}C$  and 130 rpm for 24 hours. 2.5% (by volume) of this prepared yeast was inoculated for ethanol production. Fermentations were conducted in pH-controlled fleaker fermentors, as described [37]. Each fleaker (200 ml working volume in 500 mL fleaker) was equipped with a pH probe, a needle to add fluids, a needle for sampling and a magnetic stir bar. A six-position magnetic-stirring plate was placed underneath a water bath to drive the bar at 150 rpm. 0.05 M Phosphate pH 5.5 was used as buffer and sugar concentration was maintained at 50 g/L for Glucose only. The designated volume of biomass culture was centrifuged and the cell pellet was resuspended for an initial OD (600 nm) of 0.5 in the fermentor. Fermentation parameters such as cell density, metabolic ethanol yield, volumetric ethanol productivity and specific ethanol productivity were calculated as reported by [38].

**Analytical Measurement:** The concentrations of glucose, xylose, ethanol, glycerol and xylitol in the fermentation and culture experiments were analyzed using high-performance liquid chromatography (HPLC). The HPLC system used was as reported [38]. Cell densities were measured using a UV/VIS Spectrophotometer (Beckmann Coulter DU720) at wavelength 600 nm. The absorbance reading was converted to the unit of g dry-wt/L. One unit of absorbance at wavelength 600 nm is equivalent to 0.31, 0.47, 0.33 g dry-wt/L for *Z. Mobilis* and *S. Cerevisiae* respectively.

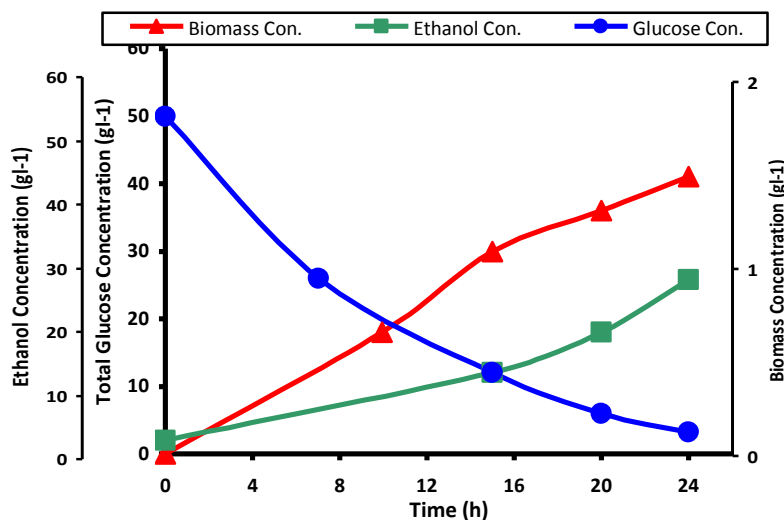
**Measurement of emissions:** The experiment for pure gasoline, a 10% ethanol-gasoline blend, and a 20% ethanol-gasoline blend was performed for 100,200 and 300 counts/10seconds at 2500 RPM. The air to fuel ratio was determined using the air flow reading and the fuel flow reading.

## III. RESULT AND DISCUSSION

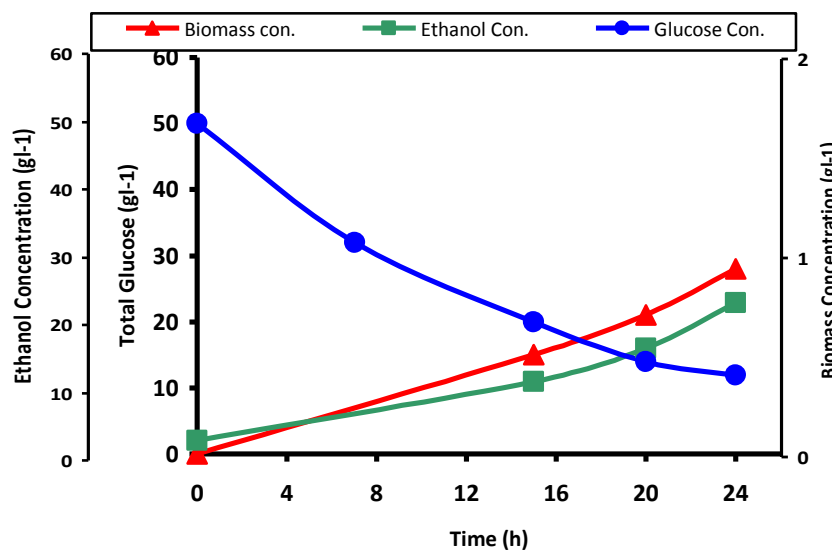
Ethanol production from agro residues involves the pre-treatment with acid or alkali, scarification, fermentation using yeast, finally separation followed by distillation. The biomasses were taken in equal amount for pre-treatment. After pre-treatment the pH of the substrate was adjusted at pH 5 and analysis for sugar determination was done by DNS method, and it was found 68, 52, 65 and 39 g/l for Sugarcane bagasse, rape straw, corncob and Wheat bran (Fig:1). After hydrolysis the result was obtained as in Table 2. The final ethanol production from glucose was calculated by the general equation of ethanol fermentation. Since according to chemical equation 92 g of ethanol is produced from 180 g of glucose unit, which means 1 g of glucose gives 0.51 g of alcohol. According to reaction the concentration of ethanol was found 34.6, 26.5, 31.5 and 22.9 g/l for Sugarcane bagasse, rape straw, and corncob and Wheat bran as shown in Table 2. For the comparative result of concentration of ethanol the sugar concentration was made equal for each biomass and it is observed that

SN.	Raw Materials	Sugarcane Bagasse	Rape Straw	Corn cob	Wheat bran
1	Biomass yield $Y_{X/S}$ ( $gg^{-1}$ )	0.015	0.014	0.040	0.010
2	Ethanol yield $Y_{P/S}$ ( $gg^{-1}$ )	0.36	0.29	0.33	0.26
3	Final biomass, ( $gl^{-1}$ )	1.49	1.32	1.28	0.92
4	Final ethanol ( $gl^{-1}$ )	34.6	26.5	31.5	22.9
5	Substrate utilized, (%)	95.90	90.80	93.52	85.42
6	Fermentation efficiency (% of theoretical)	99.01	96.5	89.2	84.6
7	Fermentation time, (h)	24	24	24	24

**Table 2:** Ethanol production by fermentation with yeast.



**Fig: 1** Fermentation of 50 gL<sup>-1</sup> Glucose (Bagasse) by Yeast (temp 28-30<sup>0</sup>C, pH5)

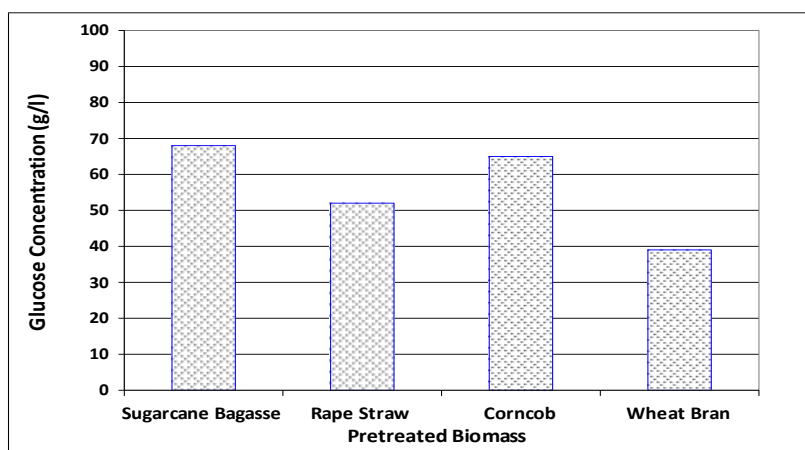


**Fig: 2** Fermentation of 50 gL<sup>-1</sup> Glucose (Wheat bran) by Yeast (temp 28-30<sup>0</sup>C, pH5)



ethanol concentration for 50 g/l of sugar of biomasses were found 25.4g/l for Sugarcane bagasse and rape straw, by utilizing 49.8g/l of glucose concentration during fermentation, while 21.2g/l was found for wheat bran by utilizing 41.5 g/l glucose as shown in Fig: 2 and Fig: 3. Similarly 24.2 g/l ethanol was found for corncob.

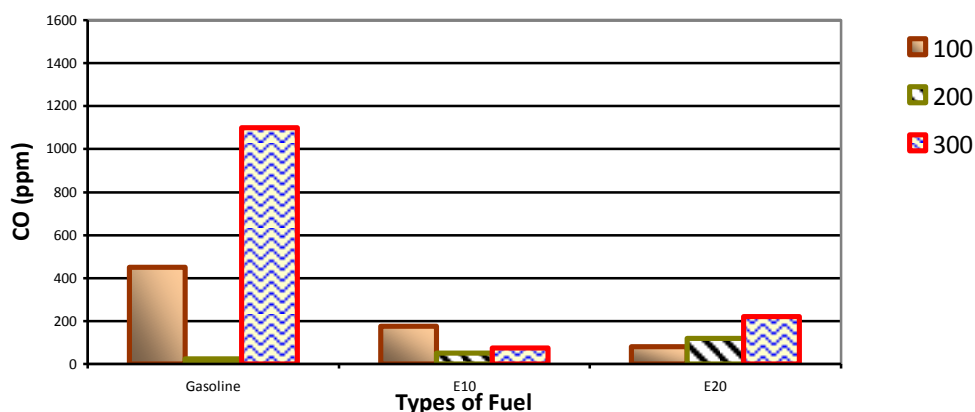




**Fig: 3** Concentration of Glucose after pretreatment of equal amount of biomasses

Since yeast is able to ferment only hexose from the pre-treated biomasses so that the yield of ethanol was found low in concentration, for better result of yield of ethanol the yeast strain is needed. The main hydrolysis product of cellulose is glucose, whereas the hemicelluloses give rise to several pentose's and hexoses. However, high lignin content blocks enzyme accessibility, causes end product inhibition, and reduces the rate and yield of hydrolysis. In addition to lignin, cellobiose and glucose also act as strong inhibitors of cellulase. Maximum Ethanol fermentation was found in 24 hours at and pH of 4.0 to 5.0 which was found similar as concluded by *Taherzadeh, M.J. et al.* However, optimal conditions may change with fermentation time. This improvement was adopted for further fermentation by using yeast strain in 28-30 hours at pH 5.

**Measurement of emissions:** Bio fuel is ecofriendly than fossil fuels because of low emission of harmful gases from the engines. A comparative study was done at a certain engine speed. At 2500 RPM of engine speed, the concentration for NO<sub>x</sub> and CO was found maximum for the gasoline for 100,200 and 300 counts/10seconds. It is safe to say that the gasoline emitted a lot more Carbon Monoxide than either of the ethanol blends. This is due to the fact that CO is formed when there is not enough oxygen for all of the carbon content of fuel to convert to Carbon Dioxide. The concentration of CO for gasoline was counted as 1100ppm in 300 counts /10second, while it was recorded maximum (450ppm) in 100 counts /10second as shown in fig.4. Ethanol is an oxygenate, therefore, ethanol blends will have more oxygen in their chemical structure than pure gasoline, decreasing the chance that the carbon from the fuel will not be able to form CO<sub>2</sub> during combustion.



**Figure 4:** displays the Carbon Monoxide emissions for all 3 fuels.

The NO<sub>x</sub> emissions for 20% ethanol on average are smaller than those of pure gasoline. 10% ethanol blend produced the highest NO<sub>x</sub> emissions at the lower two fuel flow rates. The only responsible conclusion to be made based on the data is that NO<sub>x</sub> emissions are of a similar order for all 3 fuels, meaning that all the emissions were less than 50 ppm.

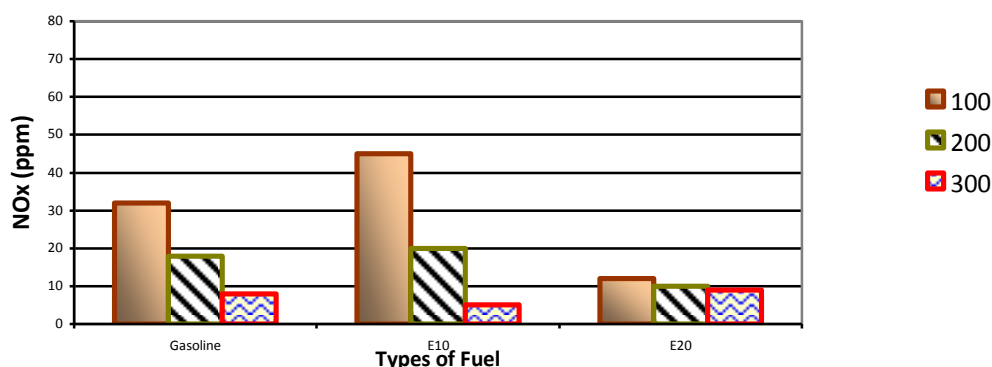


Figure 5: displays the NOx emissions for all 3 fuels.

Similarly the highest emissions of CO<sub>2</sub> were produced while operating on 20% ethanol blend. The 10% ethanol blend produced the lowest emissions. It is important to remember that, although the Carbon Dioxide emissions were highest for the 20% ethanol blend, a high Percentage of the CO<sub>2</sub> emitted by the ethanol blends will be recaptured as more ethanol is produced.

**Effect of blends on Octane Rating:** It is clear from the fig. 6, that as the ethanol blending (% of ethanol) increases in the gasoline, Octane rating becomes slightly higher. From the figure the Motor Octane number was found maximum for 100% blend, 112. While for Research Octane number it was found 118 on 100% blending.

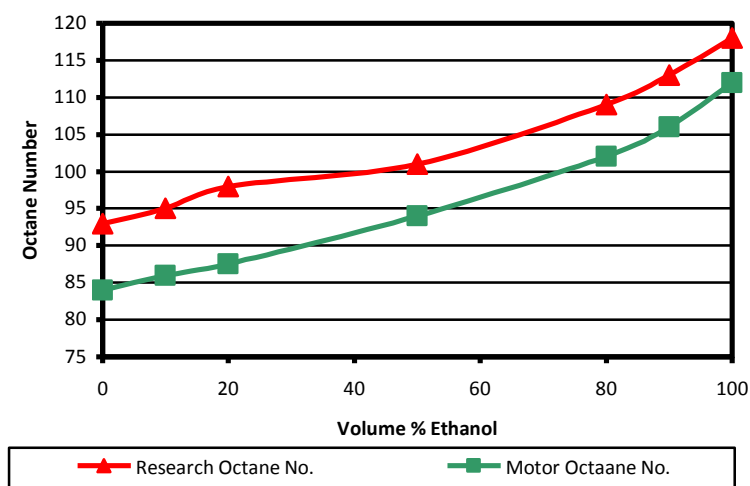


Figure 6: Effects of Blend on Octane Rating

#### IV. Conclusion:

Pretreatment is the initial step to degrade the biomass content. Pretreatment with acid autoclaving at 121°C for 30 min, is an effective and cheap parameter in comparison to enzymatic degradation and other methods. Acid pretreatment had a greater influence on the sugar release through enzymatic hydrolysis. An increase in acid severity in terms of concentration resulted in higher sugar releases. By the experimental analysis 3% of acid was found optimum. Enzymatic hydrolysis and Fermentation is the second step of pretreated biomass. Hydrolysis process are done in different ways as with dilute sulphuric acid autoclaving at 121°C for one hour, but in this step there may be the chance of formation of inhibitors or other compound, so it may be done carefully. Enzymatic hydrolysis of the pretreated biomass is an effective for the degradation of lignocellulosic biomass under optimum pH and conditions. Effective parameters of fermentation are also the important features that justified the conditions and maximum production of Alcohol. In presence of higher sugar concentration the ethanol concentration decreases. In case of different pH ethanol fermentation is more favorable at pH 5-6. Similarly higher temperature for fermentation decreases the concentration of ethanol. At different time of fermentation for hydrolyzed biomass 24 hours was found optimum. The fermentation media YEPX or YEPD was found optimum than YEP for the growth of enzymes for fermentation. Addition of nutrient supplementation as KNO<sub>3</sub>, phosphates and sulphates increases the growth of enzymes as well as alcohol concentration.

The refining, transport and combustion of bio fuels have environmental costs, particularly on local water and air quality, and these impacts could rise considerably as bio fuel production increases to meet rapidly rising global demand. At the same time, more sustainable practices and new technologies offer the potential for environmental improvements. From the study, the following conclusions can be deduced:-

1. Ethanol blends and oxygenated additives in gasoline cause improvements in engine performance and reduce exhaust emissions.
2. Ethanol-blended gasoline with oxygenated additives leads to a significant reduction in exhaust emissions. As all engine speeds, the values of CO, CO<sub>2</sub> and NO<sub>x</sub> were reduced. On the other hand, HC and O<sub>2</sub> emissions were significantly increased.
3. 10% ethanol-gasoline blends can be used in spark ignition engines without any major modifications to the air/fuel system. The 10% ethanol blend produces similar fuel conversion efficiency, brake work, to that of pure gasoline. CO emissions for 10% ethanol blends are much lower than CO emissions from gasoline. NO<sub>x</sub> and CO<sub>2</sub> emissions for 10% ethanol blends and gasoline are similar. 0% ethanol-gasoline blends do not perform as well as pure gasoline does in spark ignition engines that are calibrated to run on gasoline. The fuel conversion efficiency and brake work both decrease for an engine operating on a 20% ethanol blend. CO emissions for 20% ethanol blends are much lower than CO emissions from gasoline. The NO<sub>x</sub> emissions for 20% ethanol are similar to those of pure gasoline. CO<sub>2</sub> emissions are higher for 20% ethanol blend than for what is produced by gasoline.

Bio fuel as ethanol in the blended form with petrol is also beneficial in the reduction of environmental pollution. Ethanol represents closed carbon dioxide cycle because after burning of ethanol, the released carbon dioxide is recycled back into plant material because plants use CO<sub>2</sub> to synthesize cellulose during photosynthesis cycle. Ethanol derived from biomass is the only liquid transportation fuel that does not contribute to the green house gas effect. The combustion of bio fuels- whether blended with conventional fuels or pure-generally results in far local emissions of CO, hydrocarbons, SO<sub>2</sub> and particulate matter (and, in some instances lead) than does the combustion of petroleum fuels. Thus, the use of bio fuels, particularly in order vehicles, can significantly reduce local and regional air pollution, acid deposition and associated health problems; such as asthma, heart and lung disease and cancer. Ethanol production process only uses energy from renewable energy sources; no net carbon dioxide is added to the atmosphere, making ethanol an environmentally beneficial energy source. In addition, the toxicity of the exhaust emissions from ethanol is lower than that of petroleum sources [39, 40].

### References:

- [1] Ramanathan, M., 2000, Biochemical conversion ethanol production from root crops. In: Biomass Conversion Technologies for Agriculture and Allied Industries. Short Course Manual organised by Department of Bioenergy, Tamil Nadu Agricultural University, Coimbatore, 4-13 July, pp.157-162.
- [2] Lynch. J.M. (1992). In Proceedings of the International Composting Research Symposium (Hoitink. H.A.J. and Keener, H. eds.). 24-35.
- [3] Bjerre. A.B. et al (1996). *Biotechnol Bioeng*, 49: 568-577.
- [4] Carvalheiro F, Duarte LC, Gírio FM (2008) Hemicellulose bio refineries: a review on biomass pretreatments. *J Sci Ind Res.*, 67:849–864.
- [5] Kojima, M & T Johson (2005) Potential for Biofuels for Transport in Developing countries, Washington. DC , World Bank.
- [6] Clean Air Task Force et al (2005) Prevention of Air pollution from Ships: Reducing Shipping Emissions of Air pollution – Feasible and cost-effective Options submitted by Friends of the Earth International to the Marine Environment Protection Committee, International Maritime Organisation, 7 April.
- [7] Water Phase Separation in Oxygenated Gasoline, David Korotney, Chemical Engineer, EPA Fuels and Standards Branch, 1995, website: <http://www.epa.gov/oms/regs/fuels/rfg/waterphs.pdf>.
- [8] Earley J., T. Earley & M Straub (2005), Specific Environmental effects of trade liberalization: oil seeds, Washington, DC, International Policy council for food & Agriculture.
- [9] Sinico, S. (2005) Fill it up with Natural, *dw-world.de*, 22 September, [www.dwworld.de/dw/article/0,2144,1717299,00.html](http://www.dwworld.de/dw/article/0,2144,1717299,00.html) ; Association of the German Bio fuels Industry from Karin Retzlaff of the Association of the German Bio fuels Industry, cited in Sinico, S. (2005) Fill it up with Natural, *dw-world.de*, 22 September, [www.dw-world.de/dw/article/0,2144,1717299,00.html](http://www.dw-world.de/dw/article/0,2144,1717299,00.html).
- [10] Tate RE, Watts KC, Allen CAW, Wilkie KI. The viscosities of three biodiesel fuels at temperature up to [300] 8C. *Fuel* 2006; 85:1010–5.
- [11] Zhang X, Peterson CL, Reece D, Haws R, Moller G. Biodegradability of biodiesel in the aquatic environment. *ASAE* 1998;41(5):1423-1430.
- [12] Sharp CA, Howell SA, Jobe J. The effect of biodiesel fuels on transient emissions from modern diesel engines. Part II. Unregulated emission and chemical characterization, *SAE* 2000-01-1968; 2000, 1204-2.
- [13] Shi X, Yu Y, He H, Shudi S, Wang J, Li R. Emission characteristics using methyl soyate–ethanol–diesel fuel blends on a diesel engine. *Fuel* 2005; 84:1543–9.
- [14] Monyem A, Van Gerpen JH, Canakai M. The effect of timing and oxidation on emission from biodiesel-fueled engines. *ASAE* 2001; 44(1):35–42.
- [15] Lapuerta M, Armas O, Rodriguez-Fernandez J. Effect of biodiesel on diesel engine emissions. *Prog Energy Combust Sci* 2008; 34:198–223.
- [16] Sharp CA, Ryan III TW, Knothe G. Heavy-duty diesel engine emissions tests using special biodiesel fuels, *SAE* 2005-01-3761; 2005, 1204-2.



- [17] Ferguson, C. R. and Kirkpatrick, A. T., 2001, *Internal Combustion Engines – Applied Thermo sciences*, John Wiley & Sons, New York, pp. 1-28, 328.
- [18] Pulkrabek, W. W., 1997, *Engineering Fundamentals of the Internal Combustion Engine*, Prentice-Hall, Upper Saddle River, p. 154.
- [19] Baghdadi-Al, M., 2008, "Measurement and Prediction Study of the Effect of Ethanol Blending on the Performance and Pollutants Emission of a Four-Stroke Spark Ignition Engine," *IMEchE*, 222(D), pp. 859-873.
- [20] Bayraktar, H., 2005, "Experimental and Theoretical Investigation of Using Gasoline-Ethanol Blends in Spark-Ignition Engines," *Renewable Energy*, 30, pp. 1733-1747.
- [21] Lynd, L. R., 1996, "Overview and Evaluation of Fuel Ethanol from Cellulosic Biomass: Technology, Economics, the Environment, and Policy," *Annual Energy Review*, 21, pp. 403-406.
- [22] Kaur, P.P. et al (1998). *Biores. Technol.*, 66: 267-269.
- [23] Viesturs, U. et al (1996) *App! Biochem Biotechnol.*, 57/58: 149-360.
- [24] Cowling, E.B. and Kirk. TK (1976). *Biotechnol. Bioeng. Symp.*, 95-123.
- [25] Okeke. and Obi, SKC. (1994) *BiOl-es. Technol*, 47S 283-284.
- [26] David, et al. (1985). *App! Biochem. Biotechnol.*, 11 315-365.
- [27] Gharpuray, M.M. et al (1983). *Biotechno. Bioeng.*, 25: 157-172.
- [28] Ghosh, TK. and Bisaria. V.S. (1979). *Biotechno. Bioeng.*, 21: 131-146.
- [29] Ghosh, T.K et al (1983). *Biotechnol. Bioeng.*, 25: 2577-2590.
- [30] Nikolov. T eta! (2000). *Biores Technol*, 71: 1-4.
- [31] Viesturs, U. et al (1996) *App! Biochem Biotechnol.*, 57/58: 149-360.
- [32] Wood. TM. and Saddler, J.N (1988). *Meth. Enzymoi.*, 160 :11.
- [33] Wyk van, J.P.H. (1999). *Biores. Technol.*, 69: 269-273.
- [34] Nguyen. QA and Saddler. IN. (1991). *Biores Technol.* 85 275-282.
- [35] Ravindranath NH, Hall DO. *Biomass, energy and environment: a developing country perspective from India*. Oxford: Oxford University Press; 1995.
- [36] Smith KR. *Fuel combustion, air pollution exposure and health: the situation in developing countries*. *Annual Review of Energy and the Environment*, 1993; 18: 529–56.
- [37] Beall DS, Ohta K, Ingram LO: *Parametric studies of ethanol production form xylose and other sugars by recombinant Escherichia coli*. *Biotechnol Bioengineering* 1991, 38:296-303.
- [38] Lau MW, Dale BE, Balan V: *Ethanol fermentation of hydrolysates from ammonia fiber expansion (AFEX) treated corn Stover and distillers grain without detoxification and external nutrient supplementation*. *Biotechnol Bioengineering* 2008, 99:529-539.
- [39] Wyman CE, Hinman ND (1990). *Ethanol. Fundamentals of production from renewable feedstock's and use as transportation fuel*. *Appl. Biochem. Biotechnology*. 24/25: 735-75.
- [40] Yamada, T. and H. (1999). *BiOJOes. Techno.* 70: 61-67.