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AN INVESTIGATION ON THE PURIFICATION EFFICACY OF BIOETHANOL PRODUCTION FROM DIFFERENT SOURCES OF BIOMASS

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ABSTRACT

There are huge biomass waste disposed every day in agricultural countries that can be useful and are potential to mankind. These wastes can be useful in production of biofuels like bioethanol. In future bioethanol can be used instead of petroleum fuels that pollute our environment. In biofuel production various process like saccharification and selection of proper microbial strains are important. Using biomass to make bioethanol is cheap and help to clean waste in environment. Although the biomass sources should be used in non-crop sources as this can affect food reserves. Bioethanol as sustainable source of energy requires purification technique like rectification by further distillation done in ethanol industry. This distillation limits bioethanol production as it's expensive and has limited separation capacity. However there are other methods being research on instead of distillation like non-heating fractional distillation like use of ultrasonic irradiation, oxidation of impurities by ozone, and adsorption of impurities by activated carbon. In this research will use high sugar grasses and bagasse, then the Purification efficacy with the bioethanol production technique as discusses in the literature.

KEY WORDS: *Bioethanol, Biomass, Fermentation, Distillation, Saccharification and Purification*

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1.0 INTRODUCTION

In ethanol production, there are so many basic purposes for ethanol purification. It is simply achieved by principal distillation in an ethanol industry. However, the solid separation method through distillation has a few drawbacks, where the limit of the separation mixture are so volatile and are also exorbitant. Relatively there has been some limited research published on the field in the purification system of ethanol and its impact on distillation.

Notwithstanding, this is normal in which different techniques for purification of water and domestic sewage or industrial sewage, for instance, ozonation, adsorption, and gas stripping, are applied in ethanol production. The separation strategies of ethanol are designed to work on the quality of ethanol. The normal methods to classify and evaluate ethanol components can be derived through the use of (GC) and (HPLC). (IR) can also be utilized for the affirmation of ethanol quality. In ethanol system the use of Olfactometry combined with GC can also improves the quality as well as flavor separation of alcoholic beverages. Currently, with quick development in ethanol conception, further broad investigations on ethanol have been done lately. The recent production of ethanol, purifying, and separation procedures are assessed in this study. The extensive information on the recent ethanol study will encourage more ethanol research.

With the growth of urbanization, commercial activity, and the global population, energy consumption has increased significantly. Previously, a large percentage of the energy demand was satisfied by using conventional fossil fuel supply [1–3].Petrol subordinates, being nonrenewable source energies, which generate critical measures of ozone harming substances in the atmosphere causing extreme ecological contamination, are anticipated to exhaust soon [4,5]. In 2052 it has been proven that the oil explosion will no longer be available since the mining pace of oil is about 4billion tons per year, and in 2088 Coal explosion will also not be available, so due to this fact renewable resources has been considered. In agricultural waste which includes animal manure, municipal waste and others are considered to be a bioenergy because in order for the environment not to be hampered, this waste (biomass) are renewed as they are sustainable [8]. The conversion of fuel in biomass are used as the scale of method in applied sciences.

There are two different ways for the conversion of biomass to take place in which they are classified as the thermochemical and the biochemical process. However, biochemical constitute of the fermentation process or either through anaerobic or anaerobic digestion, in thermochemical it constitute of the pyrolysis, gasification, combustion and also liquefaction [9]. The use of biofuels is been considered as an alternatives in the United States to produce biofuels from inexhaustible biomass as well as the consideration in order to produce biofuels of about 90billions gallons(341 billion liters) in each year [10]. The investigation of production of bioethanol and the different feedstock's materials have been employed. According to data, the country highest producer of bioethanol in world is from United States of America, where they mostly generate ethanol from Corn and Brazil which is the second country with the highest producer of bioethanol generate ethanol from sugarcane. India which rank 8th produces a subsequent amount of bioethanol annually.

Table 1: Shows the amount of Bioethanol India Produces Annually

Characteristic	Million Liters
2020	2,976
2019	2,552
2018	2,693
2017	1,671
2016	2,061
2015	2,292
2014	2,002
2013	2,057
2012	2,154
2011	1,681

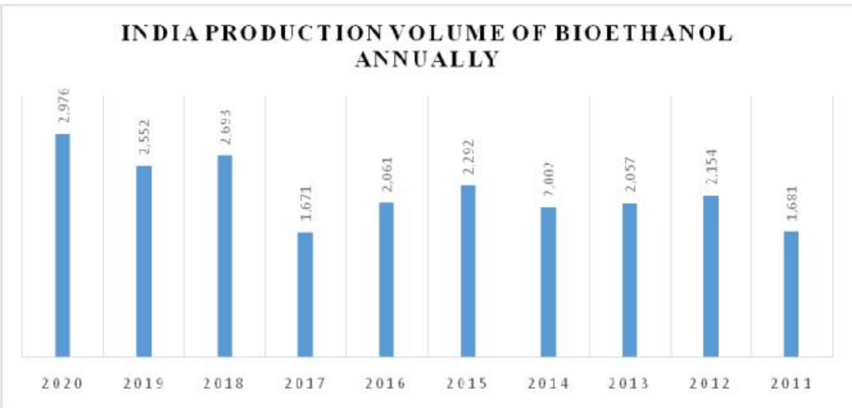

Figure 1: Shows the India Production Volume of Bioethanol in Annually.

https://www.statista.com/statistics/1052169/india-ethanol-production-volume/

Although, different agricultural waste most especially Cereal, Bagasse and wheatare utilized as a bioenergy metabolism, and they have various rates of lignocellulosic biomass resources. Where Table 2 illustrate the percentage of lignocellulosic biomass resources contains in the various agricultural waste [11].

Table 2

Agricultural Waste	Cellulose Weight Percentage	Hemicellulose Weight Percentage
corn petioles	37%	16.8%
Bagasse	40%	27%
wheat fodder	32.95	24%

Note: Author's Compilation

The level of various components like gaseous substance, various organic elements, debris residue, nitrogen, dihydrogen, oxygenate, gross calorific value or gross energy, and sulfur obtained in residuals from agriculture wastes can be achieved by the proximity and the latest investigation. Although this has been discovered that agricultural wastes have a significantly most elevated rate of a gaseous element in the scope of 61.2 – 76.05%, 14 – 24% carbon fixation valve, 38–half

Carbon, and 30 – 43% oxygenate. Residuals from agriculture wastes have a gross calorific value within the scope which ranges from 14.66 – 20.58% (MJ/kg) [12,13]. The bioethanol expansion into other fuels is the practice of a broad technique for generating sustainable energy sources. Furthermore, the bioethanol expansion into other biofuels improves the Sorption properties of the mixture of the fuel. Moreover, the other biofuels are mixtures of ethanol containing 5% and gasoline containing 95% of the compound. These can also be called E5 mixture of fuel. Table 3 shows the Physiochemical properties of bioethanol and other biofuels[14].

Table 3: Properties of both Sorption of Bioethanol and E5[14]

Fuel Characteristic	Fuel	Bioethanol
Flashpoint	24 ◦C	15 ◦C
Density at 15 ◦C	834.3 kg/m3	790.0 kg/m3
Diffusivity of momentum consistency at 40 ◦C	2.53 mm2 /s	1.130 mm2 /s
Amount of Octane	-	5.8
Hexadecane number of diesel fuel	-	110
Moisture level	100 mg kg−1	2024 mg kg−1
Heat of combusion	43.6318 MJ/kg	25.22, 26.70 MJ/kg

Source https://www.mdpi.com/2071-1050/12/20/8583

Different investigations have been published in research on the availability of biomass and the power generating from biomass in India.

According to Hossein et al. one-third of biomass only in India is enough for energy supplement in the whole country. Uddin et al. suggested that biomass in India can be obtained from agriculture, forest, metropolitanand industrial solid waste and also from animal and human fecal waste. The researchers also showed that biomass can be used in production of electricity. The research was done to find out if production of hydrogen from biomass which was different from other hydrogen production factors like pressure, catalyst effect, bed material, gasifying agents and temperature[17].This studies have showed that it's possible to have renewable energy form biomass in India.

For this to be effective, there is need to evaluate the different type of biofuels production by using specific processing technologies and feedstock like agriculture waste being utilize in bioethanol production. Although, till the recent time there are not been enough research studies that have been made to examine the capability for the production of bioethanol from residues in agricultural wastes in India. Hence, this research inspected the current literature review to emphasize the capability of these residues to create bioethanol. Notwithstanding in production of bioethanol, suitable blending is likewise strongly suggested, which will assist policymakers in considering bioethanol as an energy source in the vehicle sector.

1.1 Lignocellulosic to Bioethanol in India

There is major reason why lignocellulose feed stock should be used in bioethanol production in India. Most of bioethanol from India is from molasses which is a waste during production of sugar. This molasses accounts for approximately 11.6% in bioethanol production but molasses only cannot be enough. Feed stock based lignocellulose is need to supplement this bioethanol production. In the year 2003, was drastic decline in bioethanol production to 1518 million liters [62]. This was caused by draught that caused decrease in molasses from 10 Mt to 6.75 Mt and this cause price of molasses to increase. This pushed India to source ethanol and molasses from other countries. In 2005, the government initiatives boosted sugar cane production increasing production by 5% in the year 2006 [63]. Government initiative to increase production by 10 % in 2008 failed. It was found that tone of sugarcane produced 100kg of sugar and 40 kg of molasses that was used to produce 10 L of ethanol. When 1 tone sugarcane was used in Juice production, 70 L of ethanol was produced [64]. Increasing in population has led urge in sugar use and this requires large sugar plantations for high yields. This is difficult because there are other crops need to be cultivated alongside sugar and this make it difficult for sugar companies meets their demand.

1.2 Non-Renewable Energy Sources: A Severe Danger to the Climate

The use of fossils fuels is threat in our environment has it has caused global warming due to excessive release greenhouse gases in the atmosphere. There is need to curb this problem due to harm it poise in our planet and people living in it. The fossil fuels pollutants causing this are: CO, CO2, sulfur oxide (SO), nitrogen oxide (NO), hydrocarbon compounds, lead (Pb) and suspended particulate matter (SPM) discharged by automobiles which are harmful to humans. In 15 decades, increase in CO2 production has been recorded and this is caused by usage of fossil fuels. (http://opinion.bdnews24.com/2016/10/09/why-fossil-fuelcompanies-shouldnt-be-allowed-in-cop-22/). This threat caused leaded petrol to be banned in most countries [65]. Most of CO emissions in great cities is due to automobiles. Studies shows that CO exceeding 750ppm is lethal to humans. (http://www.pollutionissues.com/A-Bo/AirPollution.html#ixzz3eXIBaAsL).

The usage of bioethanol and biodiesel to replace fossils fuels in India in future is the promising solution to curb fuel imports and curb threat posed by fossil fuels.

Chapter Two

Literature Review

2.0 Agro-WasteTransformation into Bioethanol and Bioethanol Production from the LignocellulosicComponents of Agroforestry

Residues are isolated in a few phrases like grinding, enzyme hydrolysis production, processing, fermentation, and refinement [19]. Regarding all the activities mentioned, the requirement of enzymes is very crucial, in which all the system expense becomes more eminent. Therefore, there are there three significant processes where they are viewed as the principal factors restricting the rates and the impact of the conversions cycle of agroforestry productivity. The first procedure is the pre-treatment, the second is the fermentation process and the third process is the enzyme hydrolysis production. Pre-treatment is commonly the most part that is carried out to separate the hemicellulose and lignin from cellulose. A few kinds of pre-treatment procedures, for example, physico-chemical (wet oxidation, steam pretreatment, and hydrothermolysis), physical (processing (Milling) and granulating (Grinding), compound (natural solvents, oxidizing agents, weaken corrosive known as aciddilutions and bases), mechanical, biological, etc where all these mixtures are obtained. At that point, the hydrolyzed cellulose obtained from the enzymes to produce or to breakdown the physical, chemical and the physio-chemical components into fermented sugars. Subsequently in this progression, the conversion of this sugars to ethanols is properly made through fermentation. At long last, when the conversion of ethanol is achieved, then the application of distillation technique is improvised to refine the ethanol through separation.

Table 4 shows the different procedures associated with bioethanol production from different biomass feed stocks. Ordinarily, the pretreatment comprises of the synthetic, somatic and the Sorption processes for handling emicelluloses materials as well as their benefits and limitations [20].

Table 4

Pretreatment		Pro	Con
Synthetic	Acetic	Large quantity of cellulose provided	Economic expenses related with Acetic acids and recuperation
	The combination of bases similarly to oxidants	Ambient temperature	Duration of the abasement of products
	Enzymes that are organically	Accountable for cellulose as well as emicelluloses Chemical decomposition	High-priced
	Harries ozonolysis	Large proficiency of delignification	Consuming just as reusing of enzymes
		Low duration of the abasement of products	High measure of atmosphere needed
		Large cellulose yield	
	Neoteric Solvents	Inadequate production of poisonous inhibitor	Exorbitant Solutions
		Low duration of the abasement of products	Consuming just as reusing of enzymes
Somatic	Radiance or electromagnetic spectrum	Rapid radioactivity exchange	Inadequate radioactivity diffusion in products
		Exhort response events	
		Inadequate heat absorption	The inadequate pace of hydrolysis
		Expense is less	
		Synthetic substances are not needed at all	
		Moderate ecological conditions	
Physico-Chemical Component	Heated water solution	No enzyme condition	Not produced at a monetary system
		Minimal expense reactor development	
	Vapor discharge	Causes cellulose change and hemicelluloses micellarsolubilization	Production of harmful mixtures
		Low-Expense	Extremely high-demand necessities
	Carbonic acid gas discharge	High available surface region	

Table 4 Contd.,

		Low-Expense	
	AFE	Intensify the surface regions which can be obtained	A large quantity of ammonia is required, so cost increments
		Decrease in the arrangement of inhibitors	
	SAA	Produced at a lower climatic condition	It Costly
		Decrease in the arrangement of inhibitors	

Source: https://www.mdpi.com/2071-1050/12/20/8583

During the hydrolysis interaction of lignocellulose material, several unfavorable inhibitors, notably phenolic chemicals, derivatives of ferulic acid, and Acetic acid are inferred. After synthetic, somatic, and physio-chemical enzymatic hydrolysis, these hazardous combinations should be rapidly pulled out using a detoxification technique [21].One of the major drawbacks of hydrolysis is the arrangement of regulators and degradation. Furthermore, the pretreatment for biological activities takes longer than other pretreatment techniques, allowing for cellulose breakdown and the formation of hemicelluloses. These techniques also are biodegradable since they do not require additional procedures to handle leftover streams [22].The most well-known of all the hydrolysis processes for measuring lignocellulose compounds of biomass is enzymatic hydrolysis. Because of the high investment costs of lignocellulose catalysts, the recognition of bioethanol as a top-notch source of energy and for ecological sustainability is debatable [23]. It takes more than 26 USD per cm^3 to use cellulase catalysts for enzymatic hydrolysis in producing ethanol [24].Enzymatic saccharification, pre-treatment, and fermented products are all done in separate steps. However, both enzymatic saccharification and fermentation of biomass can be combined into a single step rather than two separate procedures [32,33,34]. There is now a need to combine these technologies for producing ethanol from lignocellulosic biomass.

2.2 Biotechnology Using Solidification through Fungi Growths: A Feasible Solvent

In some researches has been conveyed to solidify the enzymes process to give a favorable bioethanol products due to the advantages elucidated previously. A few Fungi growths are not only used to insulate lignocellulosic properties, as a result of their large effectiveness[48,49]. Then again, numerous parasitic growths do not have the ability to produce enzyme acquired to aid fermentation. Those parasites have greater performance species so they can infiltrate the substratum profoundly just as converting the substrates from lignocellulosic component to bioethanol from a solitary step to the other [29,30,31].

2.3 The Production Bioethanol through the process of Hydrolysis

The application of acid hydrolysis processes in biomass aids in the fermentation and the conversion of cellulose to bioethanol. For example, the use of bagasse is an old method of changing biomass to sugar, from sugar to ethanol. In 1819 the use of Acid hydrolysis on bagasse for the conversion of sugar was first noticed by Bracormet. In production companies where sugar is been produced from bagasse do not completely change over sugar to power. At first, it was utilized distinctly for animal feed consumptions or to make fire. After which, further research was carried out to acquire the practice of bagasse as a power supply and converting bagasse to ethanol as a means of biofuel. The application of hydrolysis methods can discharge the problems to a certain point. The use of fermentation methods can easily decompose and convert various biomasses materials to sugar and from sugar to ethanol. Figure 2 shows the conversion processes in bioethanol production.

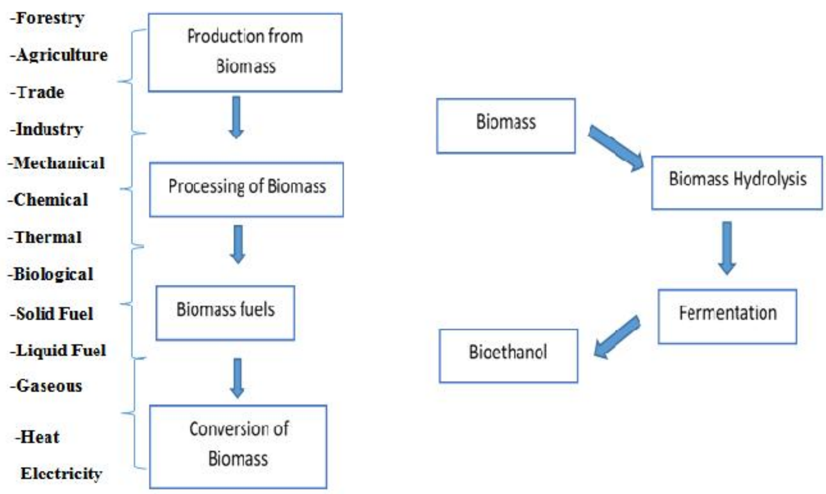

Figure 2

2.4 Fermentation and Saccharification

Pretreatment and saccharification are often used in the manufacture of bioethanol from various sources of biomass, which is subsequently converted to bioethanol via a simple fermentation process. Different yeast strains and microbes are used to generate fermentation. The selection of strains for bioethanol production is based on their utility, ethanol resistance, and inhibitors of fermentation, extreme pH, and temperature conditions. Cerevisiae is used in the majority of fermentation techniques. S. Cerevisiae is used in this experiment. Because of its strong ethanol tolerance, low optimum pH range, and requirement for anaerobic environments, S. Cerevisiae is an efficient bio-ethanol producer. Nonetheless, S. Cerevisiae is not well suited to the generation of ethanol from xylose since it necessitates strain modification or the use of bacterial enzymes to pre-treat xylose.

Chapter 3

3.0 Research Methodology

Collection of different agriculturalgrass samples of different places which has high sugar content. In this study, Bagasse, Perennial ryegrass, Dandelions, Thistles which is known as the milk Thistles are used for bioethanol production.

3.1 Materials and Methods

Bagasse were collected from industries, in this case, bagasse in many industries are used for burning which cause a lot of environmental pollution so that it may be used in the generation of biofuel. Perennialryegrass, Dandelions and Thistles were collected from difference place and were used as cellulose substrates.

3.1.1. Dry Milling

The dry processing method is more prevailing and more effective in the production of ethanol than the wet processing method. Perennialryegrass, Dandelions and Thistles were milled and sieve and was mixed Bagasse before used to form a 50 mesh sizes.

In this production, mechanical pretreatment process is obtained where the different samples are placed in the flask. Then the use of biological pretreatment process of samples where the flask are covered with cotton wool. The next step is heat pretreatment where the treated samples are filtered from the pretreated samples. Colorimetric estimation of sugars are used in the pretreated samples.

3.1.2. Fermentation of Substrates

The enzyme that was applied to the samples for fermentation was the used of cellulose which is illustrated bellow.

Cellulose + Hemicellose ⟶ Pentoses + Hexoses

During the fermentation process, the use of hydrolysis process were used, where5-10%sulphuric acidwas added to the samples at a room temperature of 80-100^{o}C and is allowed to undergo fermentation. Although, yeast is the mostly used for fermentation which produces other byproducts. This byproduct are broken-down in other for fermentation to occur, whereby the byproduct must be eradicated in other for ethanol to be produced.So after the fermentation the fermented samples was distilled.

3.1.3. Simultaneous Saccharification and Fermentation (SSF)

However, continuous fermentation process for glucose was carried out in the cellulose production at room temperature of 28^{o}c. Where PS and A.celluolyticus C-1 seed culture were incorporated to a solid liquid separation flask. And also S.Cerevisiae TJ14 seed culture of the inoculum were inoculate dalong with the culture broth containing the cellulase was applied in the solid liquid separation flask. At the room temperature of 42^{o}c, the simultaneous saccharification and fermentation occurred. Ethanol was formed at 40^{o}C.

The Advantage of SSF as followed

- Low enzyme requirement
- Shorter process of time
- Save cost

So therefore, fermentation of glucose with saccharomyces Cerevisiae helps in the aid of

- High ethanol tolerance
- Aim as a robust to other inhibitors
- Higher specific rate
- The production of ethanol a higher yield.

3.2. PurificationTechniques

In term of purification of the fermented samples, the samples in this study undergoes through steam distillation. During this stage of steam distillation process the collection of distillate was obtained. So ethanol obtained from distillated sample.

The by-products of fermentation are for the most part separated by the use of distillation. Though, the by-product from volatile compounds serves to become constant more in ethanol. Furthermore, in some cases, ethanol is not needed in high concentration, particularly for drinking or pharmaceutical purposes. Further distillation is a waste of time, money, and energy within that situation. Many investigations have been performed to develop novel procedures for the purification of ethanol that may be used instead of distillation.

These procedures are broadly classified.

3.2.1. Distillation

Distillation is the main technique used in purification of ethanol in industries. Its separate's components with different volatility in a mixture. This is whereby heated mixture separates. The low boiling point mixture becoming a vapor, then the vapor condenses and is collected as pure liquid. Distillation is the process of vaporizing and condensation over and over again. As a result, it is very expensive [59].

In separation techniques, distillation is one of the most dynamic techniques that are used for separation. Nonetheless, it includes some various problems. One of the problems is the distillation is used as a separation of compounds that are volatile.

A distillation pinnacle is used to efficiently separate water and ethanol in the production of ethanol. Water is obtained from the pinnacle's lower point, while ethanol is obtained from the pinnacle's highest point. Contaminants with similar boiling point limitations to ethanol are thought to lodge in ethanol even after distillation. The other problem is that it's expensive. Distillation is also considered as a reiteration of vaporization and condensation. Hence, it is exorbitant.

3.2.2. Adsorption

The adsorption separation technique employs a large adsorbent surface area. The physical and chemical characteristics of compounds are used to adsorb them onto the adsorbent. Furthermore, because of their low diffusivities, the larger particles tend to be adsorbed more.Likewise, chemicals having a higher relative extremity to the adsorbent surface will be adsorbed more in general. Since the polar chemicals are also those of ethanol, various sizes of particles might be present in ethanol. For example, the contaminants, non-polar surfaces, and wide-ranging pore distribution are desirable at this stage when ethanol purification is examined. Activated carbon and alumina are the most often used adsorbents in water treatment [57,58].

3.2.3. Ozonation

Ozone is a tri-atomic particle made up of three oxygen atoms. Ozone's significant oxidation potential allows it to dissolve several types of substances. Compound disintegration may result in changes in the physical and chemical properties of compounds, such as increased volatilization, biodegradability, and toxicity decrease.

Although, ethanol oxidation may be expected with oxidation, it does not occur under the climatic conditions [56]. As a result, ozone may remove the impurities while causing no damage to the ethanol. Ozonolysis is an oxidation process that does not physically eliminate chemicals. There are still some challenges in assuming that few molecules cannot be oxidized by ozone, such as non-oxidizable chemicals and by-products. These chemicals will remain stable after ozonation.

3.2.4. Gas Stripping

The differences in volatilities of chemicals are used in the gas stripping separation process. Henry's law is the single representation of separation performance. 2007 (Alley).

$$\mathbf{H} = \frac{Pvap}{Csat}$$

Where H = Henry's constant (moles/L atm)

P_{vap}= the partial pressure of a pure compound (atm), and

C_{sat}= the saturation concentration of the pure compound in the liquid phase (mols/ or mg/L) Henry's law consistently fluctuates relying upon the vapor and liquid stages. The low boiling points of a compound are simply assumed where they can be stripped more effectively. For example, acetaldehyde is one of the significant contaminants in ethanol.

Chapter 4

4.0 Result and Discussion

Bioethanol is largely produced in India, whereby Indian have been ranked among the top five producers of it. This product is produced by the anaerobic condition where molasses or simple sugars are fermented to produce ethanol. Productions of ethanol from simple sugars is still in use but producing it using lignocellulose is still not done has research are been done. If the research of using lignocellulose to produce ethanol will be successful, agriculture waste will be used to produce the bioethanol. Below is the figure 3 showing how banana pseudo stem was used as lignocellulose substrate to produce ethanol.

So therefore, the final processes of the bioethanol is showing in the diagram below.

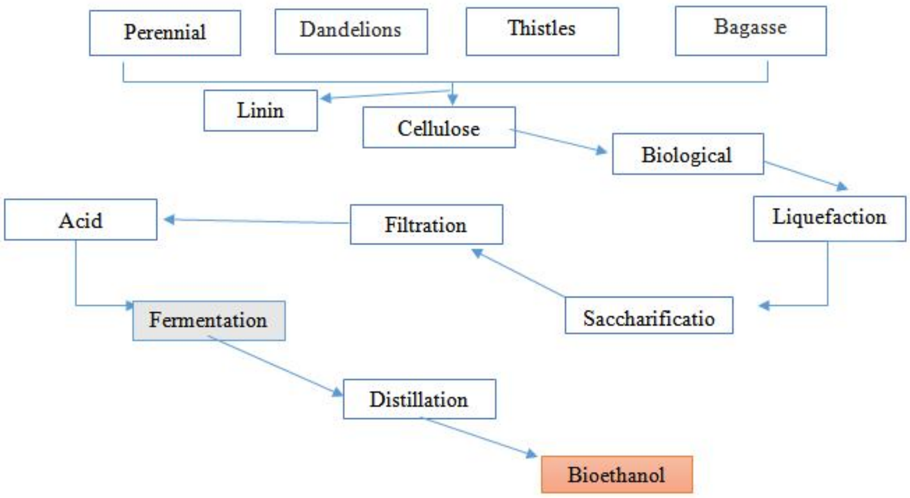

Figure 3

Author's Compilation

Graph Showing Different Ethanol Concentrations

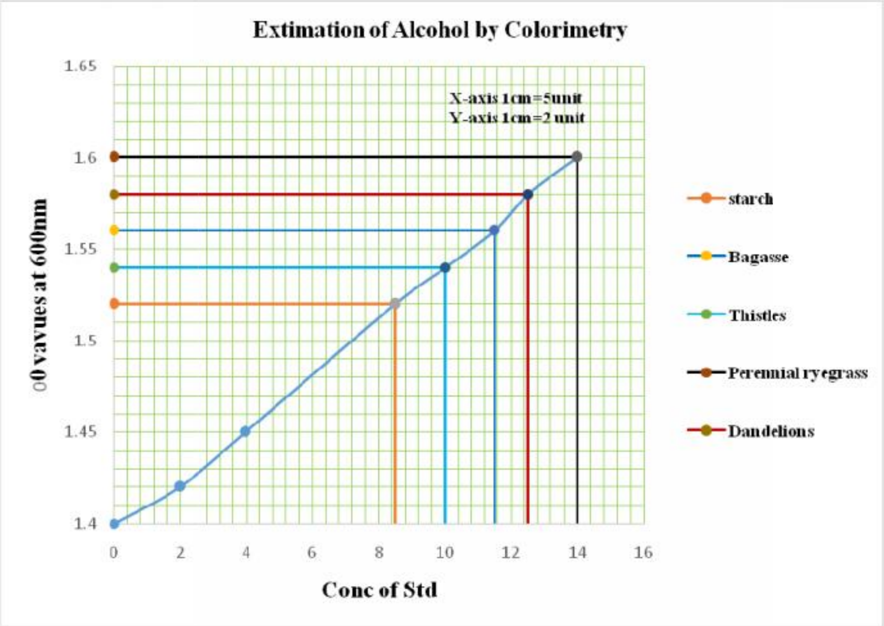

Figure 4

Author's Compilation

Though production of bioethanol from biomass is promising, there are various obstacles. The saccharification and pretreatment process are required to use non degradable lignocellulose substrate. There are also various contaminants and residues in industrial waste containing carbohydrates, making these substratesprofligate in production of bioethanol.

Chapter Five

5.0. Conclusion and Recommendation

Most of today's research programs are focused on tomorrow's fuel needs. To reduce the usage of fossil fuels and make them available to future generations as we are thinking about an alternative fuel resource which is environmental friendly and replace the role of traditional fossil fuels, we are focusing on the production of bioethanol from renewable natural resources like dried rice straw, husk, grass, bagasse, and other cellulosic materials.

In country with large population like India, usage of petroleum products fuels can be disastrous due to air pollution. Having biofuels as an alternative method can be very useful to curb this as its more environmental friendly. Lignocellulose biomass is the best for production of bioethanol as most of cereals grains or crude oil based biofuels not affordable as they are used in human and animal consumption. There is need to shift to ecofriendly energy resources and bioethanol is among them and is more economical in future. The biomass that are pollutants in the environments can be used in bioethanol production by use of microorganisms and this is cost effective where more research need to be done and this technique can be used in industrial processing. Use of biomass in production of ethanol has both environmental and economic important. It is of great importance if more research done in the bioethanol production sector to replace petroleum fuels which has negative impact on the environment.

Nomenclature

GC: Gas chromatography

HPLC: High-performance liquid chromatography

IS: Infrared spectroscopy

PS: Primary sludge

AFE: Ammonia Fiber Explosion

SSF: Simultaneous Saccharification and Fermentation

SAA: Soaking aqueous ammonia

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