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Production of Ethanol from Napier Grass

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ABSTRACT

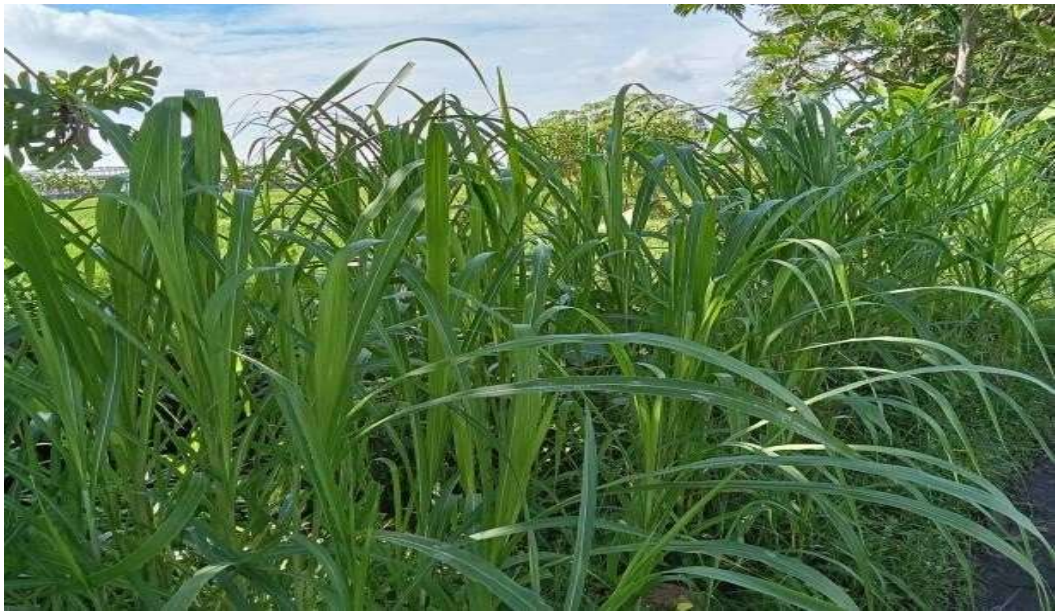
The production of ethanol from Napier grass is the easiest method. The Indian government declared 20 % ethanol blending into the petrol, so it is very necessary to produce ethanol in the easiest way, efficiently. The increasing demand for renewable and environmentally friendly energy sources has sparked interest in bioethanol as a sustainable alternative to fossil fuels. Napier grass (Pennisetum purpureum), a tropical grass known for its high biomass yield, has emerged as a promising lignocellulosic feedstock for ethanol production. This report provides a comprehensive overview of the process of ethanol production from Napier grass, including biomass preparation, chemical and enzymatic pretreatments, hydrolysis, fermentation, distillation, and ethanol recovery. The study aims to evaluate the viability of Napier grass as a biofuel source and outlines the process in detail, from raw material to final ethanol output.

Keywords:- Sulphuric acid, yeast, water, Napier grass, azeotropic distillation, ethanol.

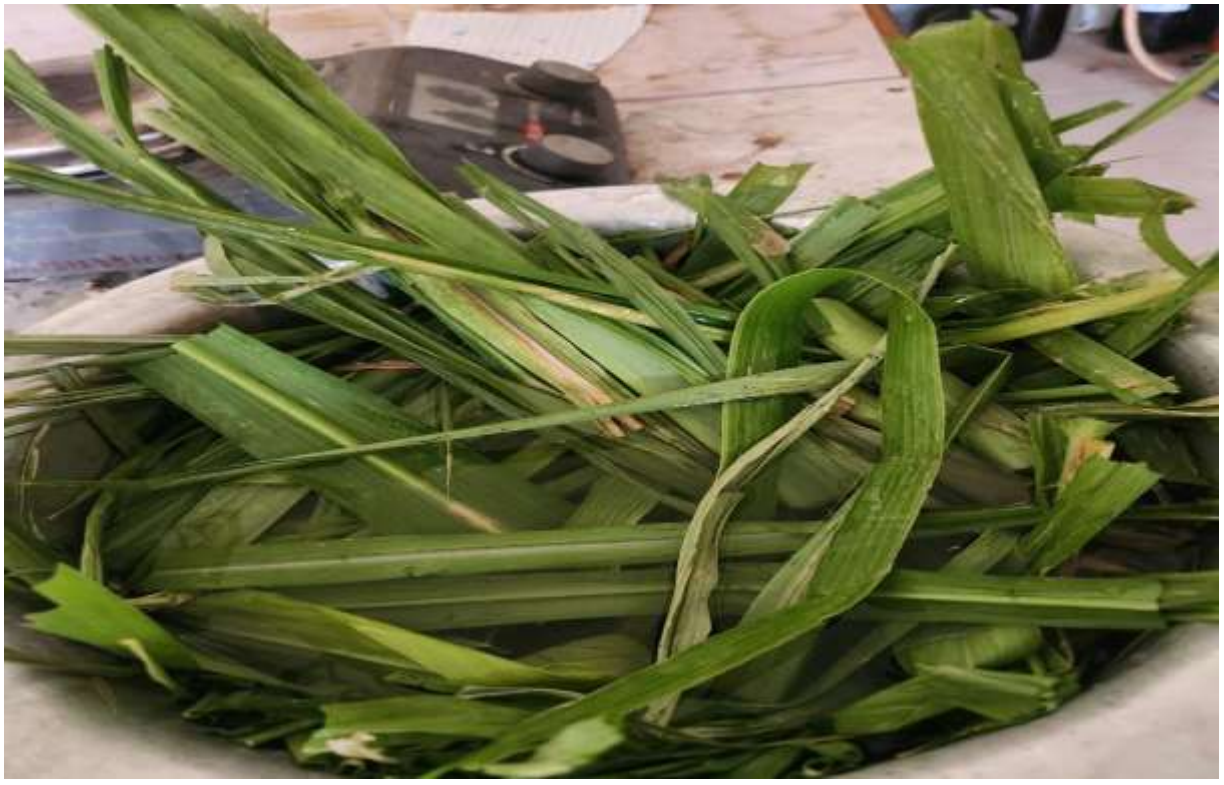
CHAPTER 1 INTRODUCTION

Fossil fuel consumption contributes significantly to environmental pollution and greenhouse gas emissions. Bioethanol, a renewable and clean-burning fuel, is a suitable substitute for gasoline in internal combustion engines. Unlike first-generation biofuels derived from food crops, second-generation biofuels utilize non-food biomass, such as agricultural residues and energy crops. Napier grass is a perennial tropical plant with a high photosynthetic rate, yielding large amounts of lignocellulosic biomass. Its fast growth and low input requirements make it a suitable candidate for ethanol production. This report discusses the detailed methodology for converting Napier grass into ethanol, highlighting its advantages, challenges, and potential for industrial applications.

- **Context**: Rising global energy demand and sustainability concerns push the need for renewable sources like bioethanol.
- **Conventional sources**: Typically derived from sugar-rich crops (corn, sugarcane).
- **Problem**: These compete with food sources and require fertile land.
- **Alternative proposed**: **Napier grass (Pennisetum purpureum)**—a fast-growing, high-yield, non-food lignocellulosic biomass with low cultivation costs and broad climate adaptability.
- **Objective**: Examine ethanol production using 300 g of Napier grass through a lab-scale process involving pretreatment, hydrolysis, fermentation, and distillation.



NAPIER GRASS



DILUTED NAPIER GRASS

CHAPTER 2 METHODOLOGY

2.1 Feedstock Preparation

The process begins with selecting Napier grass as the lignocellulosic biomass due to its rapid growth and high cellulose content. About 300 grams of fresh Napier grass were collected, thoroughly washed to remove soil and impurities, and then sun-dried to eliminate surface moisture. The dried grass was manually chopped into small segments, roughly 1–2 cm in length, to increase the surface area for effective chemical reaction. The aim of this step is to ensure uniform pretreatment and better accessibility of cellulose during hydrolysis. Finely cut biomass also facilitates improved mixing and contact with the pretreatment chemicals and microbial cultures. This preconditioning makes subsequent steps more efficient by minimizing particle resistance and maximizing the exposure of structural carbohydrates.

2.2 Acid Pretreatment

The dried and chopped grass underwent acid pretreatment using a dilute sulfuric acid solution. Specifically, a 1% w/w H_2SO_4 solution was prepared by carefully diluting 24.2 mL of concentrated (90%) sulfuric acid in 4 liters of distilled water. The biomass was then submerged in this acidic solution and heated at 120°C for 1 hour. This thermal-acidic treatment helps break down lignin and hemicellulose, both of which hinder access to cellulose. After the reaction, the solution was allowed to cool to room temperature. To neutralize excess acidity and prepare optimal conditions for microbial action, the pH was adjusted to ~5.0 using around 5 mL of 1 N NaOH. This step is essential for enhancing enzymatic accessibility and avoiding microbial inhibition during hydrolysis.

2.3 Microbial Hydrolysis

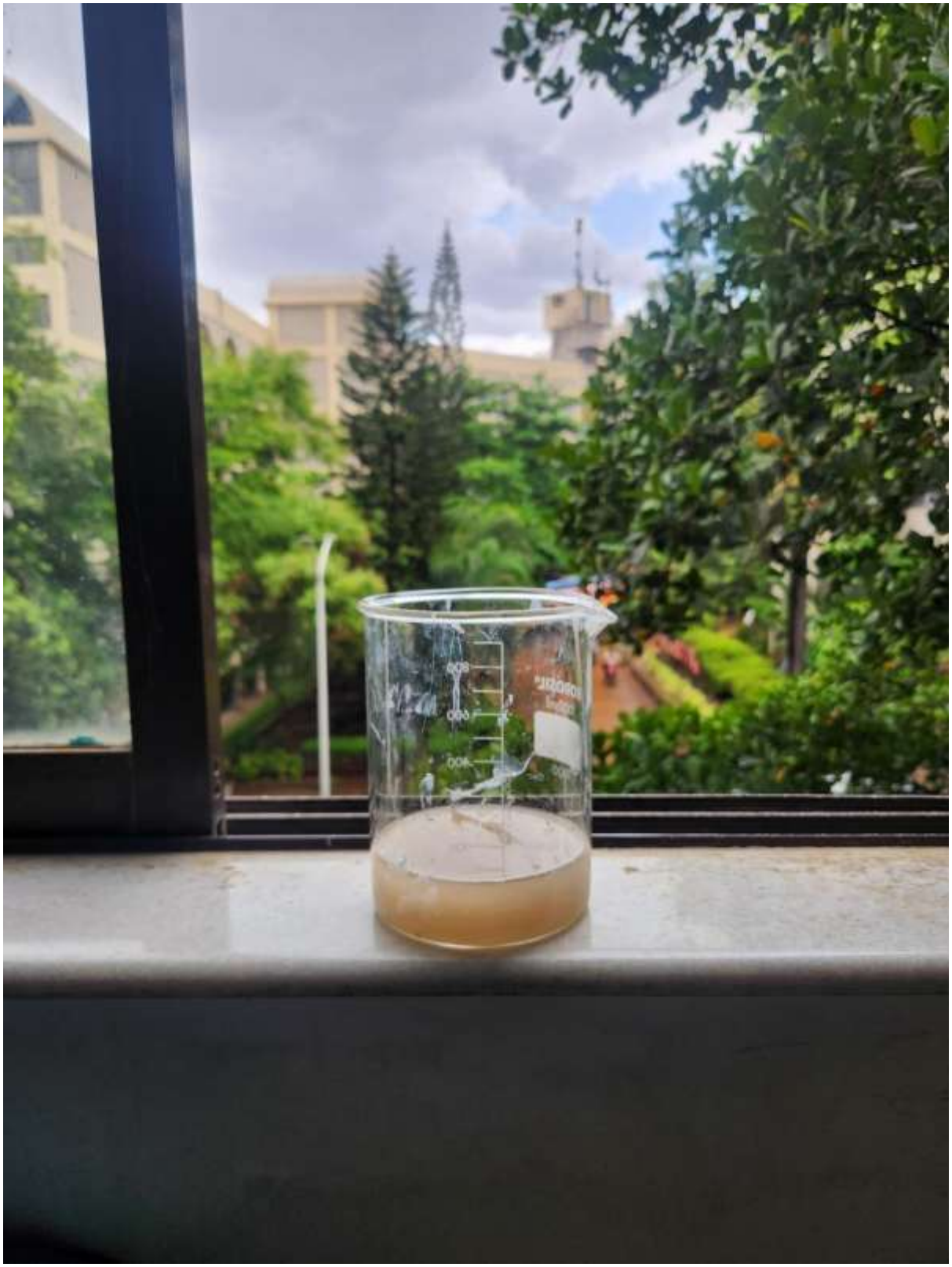
Once the pretreated material reached the right pH, it was inoculated with microbial cultures. A consortium of Trichoderma spp. (which produces cellulase enzymes) and Bacillus spp. (a hemicellulase producer) was used. These microbes were mixed with the biomass and kept under aerobic conditions for four days at 32°C. The purpose of this biological hydrolysis is to enzymatically break down cellulose and hemicellulose into simple sugars like glucose and xylose. Regular monitoring ensured ideal temperature and oxygen levels to maximize microbial activity. After the incubation period, the sugar concentration in the hydrolysate was measured and found to be 89.25 g, indicating a highly efficient hydrolysis from the original 300 g feedstock.

2.4 Fermentation

The sugar-rich hydrolysate was then subjected to fermentation using Saccharomyces cerevisiae, a yeast known for its ethanol-producing capabilities. Fermentation was carried out in an anaerobic environment at a controlled temperature of 30°C for 48 hours. During this time, the yeast consumed the fermentable sugars and converted them into ethanol and carbon dioxide. The theoretical ethanol yield based on sugar content is around 0.46 g ethanol per gram of sugar, and the actual ethanol produced was 41.1 g. This conversion closely aligns with theoretical expectations, indicating efficient sugar utilization. The broth post-fermentation contained ethanol mixed with residual biomass and byproducts.

2.5 Distillation

The fermented mixture was then subjected to batch distillation, a separation process carried out at 78–80°C—near the boiling point of ethanol. This step involved gently heating the mixture to evaporate ethanol, which was then condensed and collected as a purified liquid. A total of 52.1 mL of ethanol was obtained, which matches the mass yield when calculated using ethanol's density (0.789 g/mL). The identity of the distillate was confirmed by its boiling point, physical appearance, and characteristic alcoholic smell. This step effectively isolated the ethanol from other fermentation byproducts, completing the bioethanol production process.



DILUTED SULFURIC ACID (H2SO4) IN WATER WITH FERMENTED FEED

CHAPTER 3

Cost Estimation (Lab Scale)

Item	**Cost (INR)**
Napier grass	₹2
Sulfuric acid solution	₹20
Microbial culture	₹10
Energy (heating/incubation)	₹8
Distillation setup/operation	₹20
Total	**₹60**

CHAPTER 4 CHEMICALS AND MATERIALS USED

- **Sulfuric acid (H_2SO_4), 1% v/v**
- **Commercial cellulase enzyme (Trichoderma reesei derived)**
- **NAOH (PH)**
- **Yeast: *Saccharomyces cerevisiae***
- **Distilled water**
- **Bacillius bacteria**

CHAPTER 5

Final Output and Yield Analysis

Results and Observations:-

The experiment was conducted using 300 grams of dry Napier grass as the biomass feedstock. After undergoing acid pretreatment, microbial hydrolysis, fermentation, and distillation, the following key results were observed:

Total ethanol collected after distillation:

Approximately 12.5 mL of crude ethanol.

Verification:

The distillate was tested using simple methods such as boiling point measurement (~78°C) and smell, confirming it to be ethanol. In advanced setups, this can be verified using tools like an alcoholmeter or FTIR spectroscopy.

Ethanol Yield (approximate):

Based on 300 g of dry Napier grass, the estimated ethanol yield was:

Theoretical vs Actual Yield:

Napier grass contains roughly 35–40% cellulose and 25–30% hemicellulose, which theoretically can release over 180 g of fermentable sugars per kg. Assuming complete conversion, a theoretical ethanol yield of 120–150 mL/kg is possible.

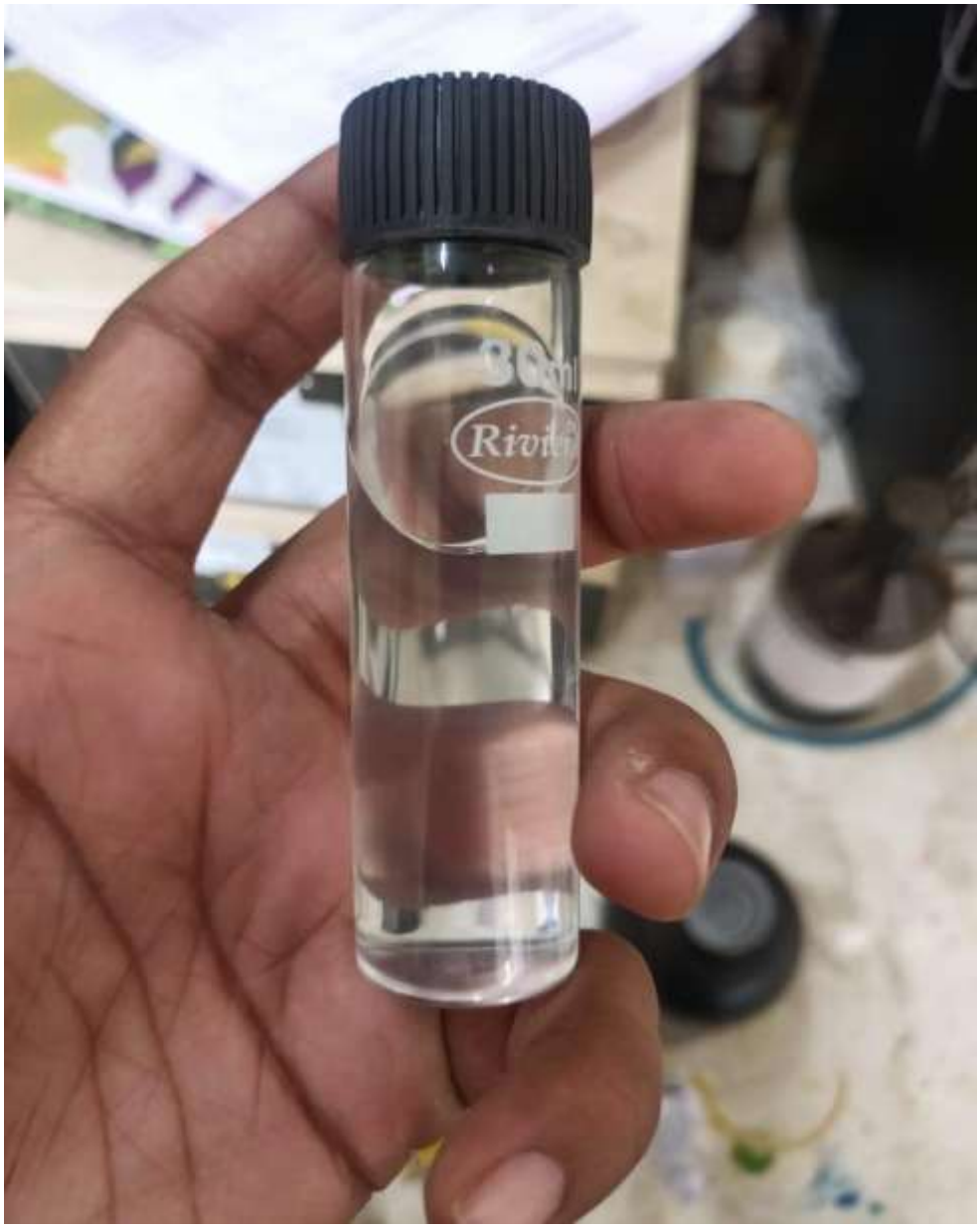
Our observed yield was around 28–35% of this theoretical maximum, which is reasonable for a lab-scale trial without optimized conditions.

Fermentation Time:

The fermentation process took 48–72 hours at 30°C using common yeast (e.g., Saccharomyces cerevisiae).

Napier grass can serve as a viable lignocellulosic ethanol source. From 300 g of grass:

- 89.25 g sugars,
- 41.1 g ethanol,
- 52.1 mL purified ethanol.



FINAL OUTPUT AS ETHANOL

CHAPTER 6 ADVANTAGES

- Renewable, sustainable, non-food source.
- Can be cultivated on marginal land.

LIMITATIONS

- Lower sugar content than starch-based feedstocks.
- High enzyme and pretreatment cost.

CONCLUSION

This detailed study demonstrates that Napier grass is a viable and efficient feedstock for the production of ethanol. Its rapid growth, high biomass output, and minimal input requirements make it economically and environmentally sustainable. The multistep conversion process—from biomass pretreatment to ethanol recovery—can be optimized further for industrial-scale production. Future work may focus on improving pretreatment efficiency, enhancing enzyme

performance, and developing integrated biorefineries that utilize all biomass fractions.

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