

Sustainable Biodiesel from Water Hyacinth and Its Performance Evaluation in Diesel Engines

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ABSTRACT: Fossil fuels such as coal, petroleum, and natural gas remain the primary energy sources for modern society; however, they are finite and rapidly depleting. To address this challenge, researchers are exploring renewable and sustainable alternatives, with biodiesel emerging as a promising solution. Therefore, attention has shifted to underutilized biomass like water hyacinth a fast-growing aquatic weed known for its high lignocellulosic content and widespread availability. Water hyacinth poses ecological threats by invading freshwater ecosystems but also offers potential as a bioenergy source. This study focuses on producing biodiesel from water hyacinth. Utilizing water hyacinth for biofuel not only helps reduce dependency on fossil fuels but also addresses environmental issues like water pollution and invasive plant management. Thus, water hyacinth serves as a sustainable, low-cost, and eco-friendly feedstock with multi-dimensional benefits in energy production and environmental protection.

KEYWORDS: Water hyacinth, Fossil fuels, Renewable energy, Bio fuel, ecological, bio energy,

I. INTRODUCTION

Water hyacinth (*Eichhornia crassipes*) is a fast-growing free-floating aquatic plant commonly found in freshwater bodies such as ponds, lakes, canals, and irrigation channels. The plant shown in the figure 1.1 was collected from **Gudivada, Andhra Pradesh, India**. This region has abundant stagnant and slow-moving water sources that favor the uncontrolled growth of water hyacinth, making it an easily available and low-cost biomass resource. Water hyacinth is considered one of the most invasive aquatic weeds in India, causing serious environmental and economic problems such as blockage of waterways, reduction in dissolved oxygen, and disruption of aquatic ecosystems. However, its high growth rate, rich lignocellulosic content, and appreciable lipid fraction make it a promising raw material for biofuel production. For biofuel applications, water hyacinth can be utilized to produce biodiesel, bioethanol, and biogas. The plant biomass contains cellulose, hemicellulose, and extractable oils that can be converted into biofuels through processes such as transesterification, fermentation, and anaerobic digestion. Using water hyacinth for biofuel production not only provides a renewable energy source but also helps in environmental management by controlling its excessive spread in local water bodies. Thus, the utilization of water hyacinth collected from Gudivada, Andhra Pradesh, serves a dual purpose: waste biomass management and sustainable biofuel generation, supporting eco-friendly energy solutions and rural resource utilization. Water hyacinth, an invasive aquatic plant, presents a dual opportunity for biofuel production as a sustainable energy source and a method for environmental cleanup. Its high lignocellulosic content, particularly cellulose and hemicellulose, can be converted into sugars through pre-treatment and enzymatic hydrolysis, which are then fermented into bioethanol. Alternatively, It can be used to extract oils for bio-diesel production via, offering environmental benefits like reduced fossil fuel dependency and greenhouse gas emission. Biofuel production from water hyacinth involves converting its lignocellulosic biomass into ethanol or biodiesel using various pretreatment and conversion methods. These methods include physical, chemical (acid/alkali), and biological (enzymatic) processes to break down the complex structure of the plant, release fermentable sugars, and facilitate the production of biofuels. Key steps include drying, grinding, pretreatment, hydrolysis to sugars, fermentation by microbes (like *Saccharomyces cerevisiae*), and distillation for ethanol, or lipid extraction for biodiesel.

II. LITERATURE REVIEW:

There are different types of bio fuels are available .so, we choose water hyacinth as a bio fuel. We studied some of those papers and those papers them are mentioned as follows:

S. M. M. Shanab.et al [1]: This study evaluates seasonally harvested water hyacinth from the Nile as a lignocellulosic feedstock for both biodiesel and bioethanol, linking biochemical composition with fuel yield and quality. Reported lipid contents (6.8–10.5%) produced 3.2–6.4% biodiesel via transesterification; fatty acid profiles were season-dependent (myristic/stearic dominant; oleic detected only in summer), implying good oxidative stability for diesel substitution. Mild acid pretreatment enhanced fermentable sugars and ethanol over 120–180 minutes, underscoring the role of low lignin and high cellulose/hemicellulose in processability. Co-products (pigments, glycerol) add valorization pathways, and measured fuel properties met local diesel standards, positioning this invasive biomass as a waste-to-resource solution for Egypt.

Ch. Vidya sagar.et al [2]: This study Framed as a narrative overview, this paper advocates non-edible, abundant feedstocks for biodiesel to avoid food–fuel competition and highlights water hyacinth’s ubiquity and low opportunity cost. It recaps base catalysed transesterification of triglycerides to FAMEs and emphasizes environmental/operational benefits (lubricity, higher flash point, lower toxic emissions) while situating hyacinth among diverse oil sources and animal fats. The contribution is primarily conceptual: arguing socio-economic co-benefits (waste control, rural income, pollution mitigation) and motivating small-scale deployments. However, it provides limited primary data on hyacinth lipid yields, extraction routes, or comparative fuel properties; references to standards (e.g., ASTM) are generic, and process variables (catalyst loading, FFA management) are not resolved. September 2025 IJSDR | Volume 10 Issue 9 ISSN:2455-2631

Priyankesh kumar.et al [3]: This paper studies have focused on identifying sustainable biodiesel feedstocks and improving diesel engine performance while reducing emissions. Non-edible and aquatic biomass such as water hyacinth has gained attention due to its rapid growth, abundance, and non-competition with food resources. Researchers have reported that biodiesel derived from water hyacinth can be successfully produced through transesterification, though it exhibits slightly lower calorific value compared to diesel. Recent literature highlights the use of metal-oxide nano-additives, especially TiO₂, to enhance combustion characteristics. TiO₂ nanoparticles improve brake thermal efficiency and reduce CO and HC emissions, though a marginal increase in NO_x emissions is often observed.

K. Prasadarao.et al [4]: The growing energy demand and environmental concerns have encouraged the use of biodiesel as an alternative fuel for diesel engines. Previous studies report that biodiesel and its blends can improve brake thermal efficiency and significantly reduce CO, HC, and smoke emissions compared to conventional diesel. Researchers such as Thangavelu et al. and Asad Naeem Shah et al. observed improved combustion characteristics and lower exhaust emissions with biodiesel blends. Optimization techniques like the Taguchi method and Grey Relational Analysis have been widely applied to evaluate multiple performance and emission parameters simultaneously. Artificial Neural Networks have also been effectively used for predicting engine behavior with high accuracy.

A. Singh.et al [5]: This experimental paper quantifies water hyacinth composition (cellulose hemicellulose 58.6%; comparatively low lignin) and develops an effective alkali pretreatment enabling near-complete cellulase hydrolysis to reducing sugars. It systematically varies NaOH/H₂SO₄ loadings, liquid–solid ratios, temperature, and time, then analyzes structural changes (FTIR, SEM) to link delignification/hemicellulose disruption with saccharification efficiency. Achieving ~100% cellulose conversion in optimized conditions, it establishes WHB as a viable lignocellulosic sugar source for downstream ethanol. The rigor of pretreatment–hydrolysis coupling and clear metrics (FPU dosing, citrate buffer conditions, yield assumptions) strengthen its translational value. Limitations include focus on saccharification rather than full fermentation/ethanol titers, and lack of inhibitor profiling (furans/phenolics) or process economics. Still, it provides a robust unit-operation backbone for WH-to-bioethanol process design.

Y. Anke.et al [6]: This recent article outlines a lab-scale route: Soxhlet extraction of hyacinth petiole lipids followed by base catalyzed transesterification to FAME, positioning WH as a renewable, waste-derived diesel substitute. It

reiterates standard biodiesel benefits and presents a schematic from extraction through methanol recovery and glycerine refining. As a teaching-style methods paper, it contributes a simple, accessible protocol suitable for academic labs or small workshops. However, critical quantitative details are sparse—oil yield from biomass, FFA content and pretreatment (e.g., esterification for high-FFA oils), catalyst levels, reaction kinetics, FAME profile, fuel properties (cetane, viscosity, CFPP), and engine performance are largely absent. Thus, its main value is procedural orientation and sustainability framing; future work should benchmark yields, conduct ASTM/EN compliance testing, and address logistics of harvesting, dewatering, and scaling lipid recovery from a low-oil aquatic plant

R. Singh.et al [7]: Targeting ethanol from waste biomass, this paper proposes a simplified, cost-effective scheme: mechanochemical activation as pretreatment, followed by fermentation and differential distillation—aiming to replace several conventional stages. It motivates aquatic plants (notably water hyacinth) due to non-competition for arable land, fast growth, and potential for water remediation; composition data (48% hemicellulose, 18% cellulose, ~3.5% lignin) underpin fermentability. The authors advocate localized, decentralized ethanol systems matched to dispersed biomass supplies to cut transport/infrastructure burdens and create rural economic benefits. While innovative in process intensification and system design, the article functions more as a conceptual/engineering proposal than a full pilot demonstration; quantitative yields, continuous-operation stability, and inhibitor/strain engineering specifics are limited in the excerpt. It points toward integrating remediation, pretreatment energy minimization, and continuous bioprocessing in practical deployments

R. Suganeshwari.et al [8]: This review centers on lignocellulosic conversion of WH to ethanol and other fuels, emphasizing pretreatment as the “make-or-break” step for cost and environmental profile. It classifies biofuels by generation, argues for WH’s low-cost availability in India, and surveys acid/alkali/other pretreatments to open the hemicellulose-rich matrix while managing inhibitors. The piece synthesizes the broader energy context (transport’s share of primary energy; biomass’s distributed availability), positioning WH within national energy/waste strategies. Its strengths are clarity and accessibility; however, it provides limited comparative kinetics, inhibitor quantification, or techno-economic/lifecycle metrics. It is a useful primer for researchers entering WH conversion, with actionable takeaways: prioritize eco-friendly, efficient pretreatment; couple with local biomass logistics; and evaluate multi-fuel portfolios (bioethanol, biogas, hydrogen) to improve plant-wide utilization

M. A. Arefin.et al [9]: This paper an early position paper reframing a notorious invasive ornamental into a prospective biofuel crop, this article argues WH’s low lignin and rapid propagation make it suitable for bioethanol and biogas production. It surveys ecological impacts (oxygen depletion, navigation and irrigation blockage) to justify valorization and suggests sustainable management via harvest-and-convert strategies. Being pre-demonstration in tone, it does not deliver detailed process performance but sets a research agenda that subsequent studies have pursued: compositional baselining, pretreatment optimization, and integrated waste-to-energy systems. Its contribution is thus catalytic—popularizing WH in the bioenergy discourse and highlighting market opportunities tied to environmental management—though modern readers should supplement it with contemporary empirical work for yields, costs, and policy frameworks

A. Bhattacharya.et al [10]: This paper proposes a dual-valorization concept: converting WH to ethanol via pretreatment hydrolysis–fermentation–purification while changeling residual fibrous fractions into furniture/handicraft products. Technically, it favors acid/alkali pretreatments and details simple drying and NaOH soaking steps as accessible routes to open the plant matrix and increase sugar release. The work is exploratory: it lacks mass/energy balances, product property testing, or durability metrics for furniture composites, and ethanol yield data are limited. Nonetheless, it anticipates the contemporary “biorefinery + circular economy” IJSDR2509071 International Journal of Scientific Development and Research (IJSDR) www.ijedr.org a592 ISSN:2455-2631 September 2025 IJSDR | Volume 10 Issue 9 framing by coupling environmental remediation with diversified product streams, inviting follow-up on material engineering (binders, durability), fuel specs compliance, and village-scale enterprise models

I. Bergie.et al [11]: This article explores the Pantanal wetland’s enormous biomass potential, especially water hyacinth, for biofuel production. It emphasizes concepts of ecosystem surplus and renewability, arguing that biomass can be harvested sustainably without harming ecological resilience. Using published hydrology and productivity data, the authors estimate biomass availability, energy balance, and carbon offsets.. The paper’s strength lies in reframing invasive biomass as an ecosystem service, linking wetland management, climate mitigation, and socioeconomics.

However, it lacks experimental conversion trials and relies on first-order estimations. It serves as a conceptual model for sustainable wetland bio economies, adaptable to other wetlands worldwide, though techno economic and policy details remain undeveloped.

A. Kumari.et al [12]: This study presents an integrated approach to derive both ethanol and biodiesel from water hyacinth using combined pretreatments. Biomass was dried, milled, and subjected to alkali and enzymatic hydrolysis with cellulase, releasing sugars for fermentation by *Saccharomyces cerevisiae*. Parallel Soxhlet lipid extraction yielded 8 g oil/100 g biomass, of which 90% converted to biodiesel. Ethanol production reached 8.1 mL/100 g, with glucose yields of 25 g/L. FTIR, UV-Vis, and HPLC confirmed fuel quality. Strengths include its holistic scope—bioethanol and biodiesel from the same feedstock—demonstrating dual valorization and potential circular economy benefits. However, yields are modest compared to terrestrial crops, and scale-up issues such as dewatering, inhibitor control, and process economics are not addressed. The paper effectively validates laboratory-scale feasibility of WH as a dual biofuel source and highlights its ecological value as an invasive species solution, yet practical deployment demands techno-economic analysis and optimization

M. A. Bote.et al [13]: This review synthesizes global research on water hyacinth as a biofuel resource, positioning it as both an ecological nuisance and an energy opportunity. It outlines biofuel pathways: ethanol, methanol, biodiesel, and biogas, with attention to pretreatment needs for lignocellulose saccharification. Citing studies on acid/alkali hydrolysis, it identifies sulfuric acid as particularly effective for sugar release. Beyond fuels, it notes ancillary uses like vermicomposting and pelletization for solid fuels. The review situates WH in India and globally, emphasizing its invasiveness, rapid biomass accumulation, and biodiversity impacts, which justify valorization. However, it remains largely descriptive, with limited quantitative comparison of yields or energy balances, and does not deeply analyze process economics or scalability. It is most valuable as a literature survey motivating further applied studies in pretreatment optimization, integrated biorefineries, and decentralized energy model

O. P. Ilo.et al [14]: This original study investigates fungal pretreatment of water hyacinth for improved pyrolysis, applying *Trichoderma atroviride*—a novel approach. The pretreatment enhanced cellulose content (+25.4%) while reducing lignin (−23.4%), yielding higher pyrolysis oil (+25.8%) and less char. Optimization via response surface methodology identified temperature and particle size as key variables. The work advances the concept of biorefineries in a circular economy, showing biological delignification can enhance downstream thermochemical conversion without harsh chemicals. Limitations include scale: fungal pretreatment is time-intensive and may face challenges in industrial throughput. Moreover, oil stability and upgrading were not fully addressed. Nonetheless, this is an innovative step linking sustainable pretreatment with thermochemical valorization of invasive biomass, offering pathways for policy and industrial interest in resource recovery from aquatic weeds

S. Sukarni.et al [15]: This characterization study analyzes WH biomass from Indonesian dams using proximate and elemental analyses (SEM-EDX, bomb calorimetry). Results: high oxygen (49.5%), moderate carbon (14.5%), volatile matter (61.2%), fixed carbon (13.8%), ash (20.1%), and a gross calorific value of 14.46 MJ/kg. These figures show WH has lower energy density than wood or coal but high volatiles, suggesting suitability for co-combustion. The study's strength lies in providing baseline data on WH's chemical and thermal properties, crucial for process modeling and technology choice (combustion, gasification, co-firing). However, its focus is narrow: no experimental conversion tests or comparisons to other aquatic biomass. Limitations include high ash content, which may cause fouling, and low calorific value, limiting standalone use. Nonetheless, the paper establishes WH as a supplemental, sustainable feedstock in mixed fuel systems and supports its use in hybrid energy strategies

A. Das,.et al [16]: This paper experimentally demonstrates dilute-acid pretreatment (2% H₂SO₄, high T/P) followed by enzymatic hydrolysis and mixed fermentation (*S. cerevisiae* + *Z. mobilis*). Optimized saccharification yielded 425.6 mg sugar/g biomass, while ethanol reached 13.6 mg/mL under central composite design. The study highlights key parameters—cellulase load (30 FPU), pH (5.5), temperature (50 °C)—for maximal efficiency. It frames WH as ideal due to low lignin, high cellulose, fast growth, and non-competition with croplands. Strengths include integration of pretreatment, saccharification, and fermentation, and statistical optimization. Limitations: ethanol yield per biomass unit is moderate, with no scale-up economics or inhibitor detoxification studies. Still, this is one of the more detailed

lab-to-process studies, providing a strong basis for industrial WH ethanol production, particularly in tropical regions where the weed is abundant

J. Onyango.et al [17]: This study explores WH for solid biofuels, producing briquettes with binders (molasses, eucalyptus leaf powder, phytoplankton scum). Physical tests assessed density, durability, water resistance, and calorific value. Molasses-based briquettes achieved 1148 kJ/kg, eucalyptus-based 1090 kJ/kg, compared to 1423 kJ/kg for charcoal. WH briquettes showed adequate durability and resistance but lower energy density. The paper emphasizes WH's cellulose/hemicellulose content as suitable for solid fuel, while valorizing invasive biomass. Strengths: experimental validation of briquetting, binder comparison, and performance benchmarking. Weaknesses: calorific values remain low relative to coal/charcoal, limiting competitiveness; no emissions or long term combustion studies. Nonetheless, it demonstrates a viable pathway for WH utilization in household/cottage industries, particularly in rural areas needing low-cost solid fuels, aligning waste management with local energy.

D. R. Suminar.et al [18]: This study investigates the use of coconut shells and water hyacinth to produce sulfonated carbon-based heterogeneous acid catalysts for biodiesel synthesis. The raw materials were carbonized at 300 °C and sulfonated with concentrated H₂SO₄ at 150 °C under varying times and cycles. Water hyacinth achieved a higher acid concentration (1.2 mmol/g) than coconut shell (1.215 mmol/g) after triple sulfonation. In esterification tests, the water hyacinth catalyst achieved better free fatty acid conversion (75.28%) compared to coconut shell (57.62%). Kinetic studies revealed faster reaction rates with water hyacinth (0.0139 L/mol·h). FTIR confirmed S=O functional groups from -SO₃H, SEM showed amorphous surface morphologies, and XRD confirmed non-crystalline structures. Results indicate that both biomass wastes are suitable for catalyst synthesis, but water hyacinth demonstrates greater catalytic efficiency, making it a promising low-cost renewable option for biodiesel production.

K. Nahar.et al [19]: In This article investigates WH as a dual-purpose biomass: biofuel feedstock and phytoremediation agent. Lab experiments in Dhaka tested WH in eutrophic lakes, showing significant water-quality **improvements (reduced turbidity, TDS, NaCl, EC; increased DO, pH). The harvested biomass was then proposed for** bioethanol and biogas production. Framed as a “three in-one nexus,” WH supports energy generation, water purification, and eco-product development. Strengths include the novel coupling of ecosystem service (remediation) with energy recovery, and empirical data on pollutant removal. Weaknesses: biofuel conversion results are not deeply quantified, and economic feasibility is not discussed. Still, it contributes to sustainable resource management literature, particularly in urbanizing regions where WH poses ecological and socio-economic challenges. It highlights the potential of turning environmental liability into a renewable energy asset.

T. Paul.et al [20]: This research explores bioethanol production from water hyacinth, an invasive aquatic weed with high cellulose and hemicellulose content. The biomass underwent dilute sulfuric acid pretreatment under high temperature and pressure to break down hemicellulose and expose cellulose. Enzymatic saccharification under optimized conditions (30 FPU cellulase, pH 5.5, 50 °C, 24 h) yielded 425.6 mg/g reducing sugars. Mixed fermentation using *Saccharomyces cerevisiae* and *Zymomonas mobilis* optimized through central composite design produced 13.6 mg/ml ethanol. SEM analysis confirmed structural disruption of pretreated biomass, while compositional analysis revealed reduced hemicellulose and increased accessible cellulose. The study highlights water hyacinth as a cost-effective, non-food bioethanol feedstock that avoids competition with arable land, while also addressing environmental issues such as waterway blockage and biodiversity loss. The results support water hyacinth's dual role in bioenergy generation and ecological management.

III. METHODOLOGY

The Methodology involves transesterification for production, and the reaction shown the figure 1 below and done the production of biofuel from water hyacinth, then followed by testing in a dynamometer-equipped engine to measure performance (torque, power, efficiency, fuel consumption) and emissions (CO, HC, Smoke, NOx) using sensors and analysers, comparing various blends (e.g. B20, B30) to diesel. The methodology adopted for the production of biofuel from water hyacinth focuses on converting lignocellulosic biomass into usable bioethanol through a sequence of physical, chemical, processes. Water hyacinth, an invasive aquatic weed rich in cellulose and hemicellulose, is selected as the raw material due to its abundance, low cost, and environmental impact. systematic approach ensures efficient conversion of biomass into renewable fuel while addressing weed management and sustainability.

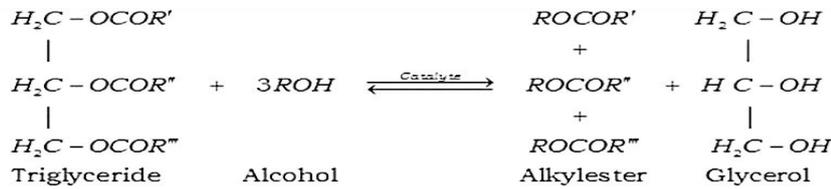


Figure 1: Transesterification reaction

3.1 Process of Biofuel Production from Water Hyacinth



Figure 2: Block Diagram of Biofuel Production from Water Hyacinth

IV. EXPERIMENTATION

The experimentation process for biofuel production from water hyacinth by transesterification method and evaluated the fuel properties and then testing the engine performance. The material required are water hyacinth biomass, methanol, NaOH or KOH, and sulfuric acid. Equipment like Soxhlet extraction apparatus, heating mantle, magnetic stirrer with hot place, separating funnel, hot air oven, thermometer, weighing balance, beakers and conical flasks.

4.1 Procedure for production of biofuel

Step 1: Collection and Preparation of Biomass

Water hyacinth plants were collected from a local water body in GUDIVADA, ANDHRA PRADESH, INDIA and washed thoroughly to remove dirt and impurities as shown in the figure 3. The plants were sun dried followed by oven drying at 60–70 °C until moisture was completely removed as shown in figure 4. Then the dried biomass was ground into fine powder as shown in figure 5



Figure 3: Water Hyacinth Weed



Figure 4: Dried Weed of Water Hyacinth

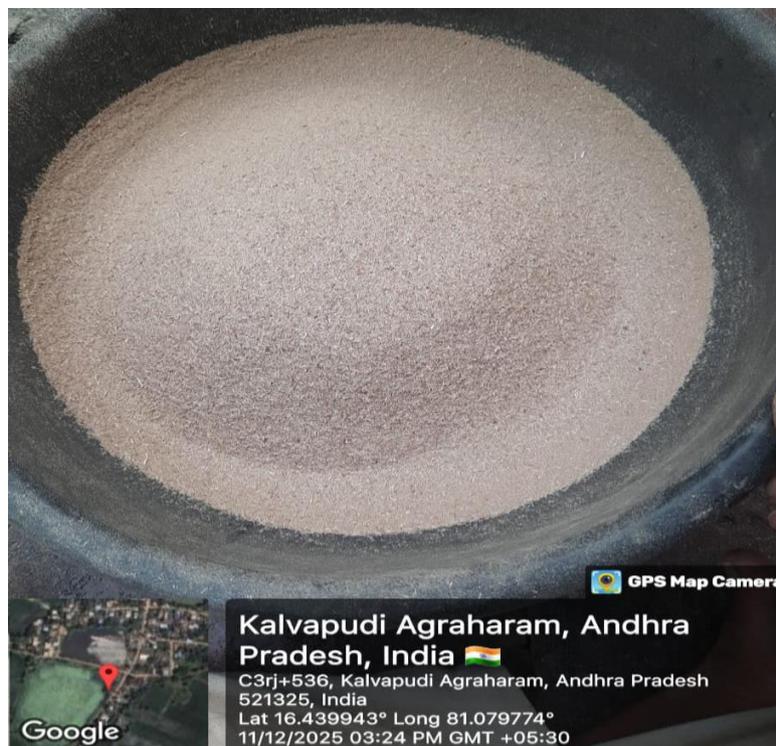


Figure 5: Fine Powder from Biomass

Step 2: Oil Extraction

The powdered biomass was subjected to solvent extraction using a Soxhlet extractor with n-hexane as solvent. The extraction was carried out for 6–8 hours. After extraction, the solvent was evaporated to obtain crude oil as shown in figure 6



Figure 6: Oil extraction

Step 3: Oil Pretreatment

The extracted oil was filtered to remove solid impurities. Free Fatty Acid (FFA) content was measured. If FFA content was more than 2%, acid esterification was performed using methanol figure 7 and sulfuric acid figure 8 to reduce FFA levels .



Figure 7: Methanol



Figure 8: sodium pellets

Step 4: Preparation of Catalyst Solution



Figure 9: Preparation of catalyst solution

A measured quantity of NaOH/KOH was dissolved in methanol to prepare sodium/potassium methoxide. The solution was stirred continuously until the catalyst was completely dissolved as shown in the figure 9

Step 5: Transesterification Reaction

Transesterification converts oils into biodiesel and glycerol. The process involves reacting triglycerides with an alcohol (e.g., methanol) and a catalyst (e.g., NaOH). The mixture is stirred and heated (60°C), then separated into biodiesel and glycerol. Key factors include catalyst type, alcohol-to-oil ratio (typically 6:1), temperature, and time. This process is used for biodiesel production from various feedstocks, including water hyacinth oil, offering a sustainable alternative to fossil fuels. The reaction is efficient, producing high-quality biodiesel with minimal waste. Transesterification is a crucial step in biodiesel production, making it a vital process in renewable energy. The pretreated oil was heated to 60 °C and the methoxide solution was added slowly. The mixture was stirred at constant speed for 60–90 minutes while maintaining the temperature between 55–65 °C. The reaction as shown in the figure 10

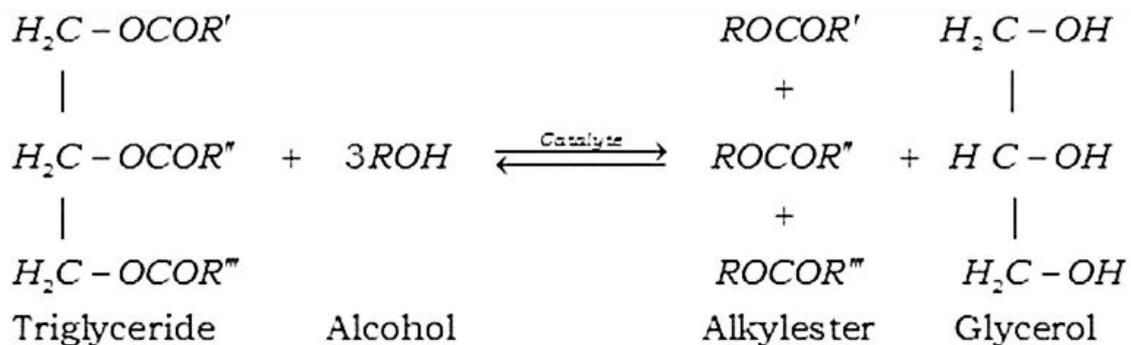


Figure 10: Reaction of transesterification

Step 6: Separation

After completion of the reaction, the mixture was transferred to a separating funnel and allowed to settle for 8–12 hours. Two layers formed, as shown in figure 11

Upper layer: Biodiesel (Fatty Acid Methyl Ester)

Lower layer: Glycerol



Figure 11: Separation of layers

Step 7: Washing of Biodiesel

The crude biodiesel was washed gently with warm distilled water to remove residual catalyst, soap, and methanol. Washing was repeated until clear wash water was obtained.

Step 8: Drying of Biodiesel

The washed biodiesel was heated at 100–105 °C to remove moisture content. The final biodiesel obtained was clear and free from water as shown in the figure 12



Figure 12: Final biofuel

Step 9: Fuel Property Testing

The produced biodiesel was tested for:

Density

Kinematic viscosity

Flash point
Fire point
Calorific value

Step 10: Blend Preparation

Preparation of Biodiesel–Diesel Blends

After obtaining moisture-free biodiesel (B100), biodiesel–diesel blends were prepared on a volume basis. The required quantity of biodiesel was mixed with commercial diesel fuel and stirred thoroughly to obtain a homogeneous mixture.

Common blends used:

B20 – 20% Biodiesel + 80% Diesel

B40 – 40% Biodiesel + 60% Diesel

We used the B20 and B40 blends. These blends were then used for engine performance and emission analysis.

V. ENGINE PERFORMANCE TESTING

1. Engine Performance Testing

Engine performance testing is carried out to evaluate how a diesel engine behaves when operated with biodiesel–diesel blends such as B20 (20% biodiesel + 80% diesel) and B40 (40% biodiesel + 60% diesel).

The results are compared with neat diesel to study the effect of biodiesel on power output, efficiency, and fuel consumption.

2. Fuels Used

Diesel (Baseline fuel)

B20 Blend – 20% biodiesel + 80% diesel

B40 Blend – 40% biodiesel + 60% diesel

(Biodiesel produced from water hyacinth through transesterification). Blends are shown in the figure 13)

3. Experimental Setup

The performance test is conducted on a single-cylinder, four-stroke, water-cooled diesel engine coupled with:

Rope brake / Eddy current dynamometer – for load application

Fuel measuring burette – for fuel consumption

Stopwatch – for time measurement

Tachometer – for engine speed

Cooling water & exhaust gas measurement setup.



Figure 13: B20 AN B40 Blends

4. Testing Procedure

The engine is started using diesel fuel and allowed to reach steady operating conditions.

The engine speed is maintained different with the load as shown in figure 14.

For each load:

Time taken for a known volume of fuel is recorded

Brake load, speed, and temperatures are noted

The same procedure is repeated for B20 and B40 blends.
All readings are used to calculate performance parameters.

5. Performance Parameters and Calculations

- * **Fuel Consumption** (mf) = (Volume flow rate × Density of fuel)
- * **Brake Power** (BP) = $(2 \times \pi \times N \times T) / 60$
- * **Indicated Power** (IP) = $(P_m \times L \times A \times n \times k) / 60$ (Watts)
- * **Brake Thermal Efficiency** (BTE) = (Brake Power) / (Fuel Energy Input)
- * **Indicated Thermal Efficiency** (ITE) = (Indicated Power) / (Fuel Energy Input)
- * **Mechanical Efficiency** = (Brake Power / Indicated Power) × 100%

VI. RESULT AND DISCUSSION

Below is a ready-to-use “Results and Discussion” section tailored for your project on biofuel production from water hyacinth and engine performance testing using B20 and B40 blends. It is written in academic/engineering report style, suitable for a final-year project or journal format.

6.1 Results of Biofuel Production from Water Hyacinth

Water hyacinth was successfully converted into biodiesel through the transesterification process. After drying, oil extraction, and chemical conversion, a clear fatty acid methyl ester (FAME) was obtained. The biofuel, diesel, B20 and B40 properties are mentioned below table 1.

Table 1: Properties of biofuel, diesel, B20 and B40

SNO	PROPERTY	Diesel	B20	B40	Biofuel	
1	Density(kg/m)	830	835	850	868	
2	Kinematic Viscosity(mm/s)		3.0	300	3.8	4.0
3	Caloric Value (m/kg)		45	39	36	36
4	Flash point(c)		70	0	110	120
5	Fire point(c)		85	92	120	130

The produced biodiesel met the basic fuel quality requirements necessary for diesel engine testing. The conversion process yielded a satisfactory amount of biodiesel, indicating that water hyacinth is a viable non-edible and sustainable feedstock. The fuel showed good miscibility with diesel, allowing the preparation of B20 (20% biodiesel + 80% diesel) and B40 (40% biodiesel + 60% diesel) blends without phase separation.

6.2 Result of Engine performance testing

Engine performance tests were conducted on a single-cylinder CI engine using B20 and B40 biodiesel blends produced from water hyacinth. The experiment was carried out at different load conditions by varying the brake load (0, 4, 8, and 12 kg) while maintaining a brake drum radius of 55 mm. Performance parameters such as Brake Power (BP), Indicated Power (IP), Fuel Consumption, Mechanical Efficiency, Brake Thermal Efficiency (BTE), and Indicated Thermal Efficiency (ITE) were evaluated. From the experimental investigation, it is observed that B40 blend exhibits superior thermal performance compared to B20, while maintaining comparable brake power. Hence, B40 can be considered a more efficient alternative fuel blend at higher loads without compromising engine output.

VII.CONCLUSION

In this project, biodiesel was successfully produced from water hyacinth, an abundant and invasive aquatic plant, using the transesterification process. The produced biodiesel was blended with diesel to obtain B20 and B40 blends and tested on a single-cylinder compression ignition engine to evaluate performance and emission characteristics. The biodiesel blend produced from water hyacinth exhibits promising fuel properties for alternative energy applications. With a density of 862 kg/m³ and kinematic viscosity of 4.1 mm²/s, the blend is suitable for engine injection and

atomization. The flash point (120°C) and fire point (130°C) indicate safe handling and storage. The calorific value (36 MJ/kg) suggests decent energy content, though slightly lower than conventional diesel. Engine performance testing of B20 and B40 blends at 1500 rpm shows B40 has better combustion efficiency, with higher brake power (2.93 kW), brake thermal efficiency (23.08%), and indicated thermal efficiency (48.27%). B20 shows slightly better mechanical efficiency (47.62%). Fuel consumption at full load is comparable (0.00032 kg/hr). Overall, water hyacinth-based biodiesel blends demonstrate potential as renewable alternatives to fossil diesel, with scope for further optimization. Further research on emissions, long-term engine performance, and scale-up production is recommended to enhance viability.

Future Scope

Although promising results were obtained in this study, further research can be carried out to enhance the performance and applicability of water hyacinth biodiesel. The following future scope is suggested:

Higher Blend Ratios: Performance and emission studies can be extended to B60, B80, and B100 with suitable engine modifications.

Engine Modification Studies: Optimization of injection timing, injection pressure, and compression ratio can be studied to improve B40 and higher blend performance.

Emission Control Techniques: Techniques such as exhaust gas recirculation (EGR) or after-treatment devices can be used to reduce NO_x emissions.

Additives and Nano-fuel Blends: Use of fuel additives or nano-particles to improve combustion efficiency and reduce emissions.

Long-Term Engine Durability Tests: Extended testing can be carried out to study engine wear, injector deposits, and lubrication effects.

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