

Sustainable Biofuel Production From Water Hyacinth (*Eicchornia Crassipes*)

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Abstract: A major source of energy for our dynamic society is the burning of fossil fuels such as coal, petroleum and natural gas. These sources of energy have been found to have limited amounts available, and therefore are said to be depleting resources. Scientists are continuously looking to find alternatives to fossil fuels. One such alternative is using vegetable oils to make fuel. This is achieved by the replacement of petroleum by renewable energy i.e., biodiesel from ecosystems and agro ecosystems which represents a central strategy to mitigate and to adapt to climate changes and it is eco-friendly, renewable and more biodegradable. Biodiesel is a much better lubricant than petro-diesel and extends engine life. There are number of vegetable oils are available, like *Jatropha curcas*, *Pongamea glabra*, *Salvalora oleoides*, *Madhuca indica*, *Azadiracta indica*, *Piper nigrum*, castor, coconut, sunflower, ground nut, palm trees etc. But all these have their own medicinal values and other important uses rather than the production of biodiesel. So, while selecting the best one, it should be considered that such a raw material is to be selected which is abundantly available in all times at any place and which is not useful for other purpose rather than the production of bio-diesel. As the search for alternatives to fossil fuel intensifies in this age of modernization and industrialization, fuelled by increasing energy costs, water hyacinth holds a strong promise in the 21st century biofuel industry. So, an attempt was made to produce biodiesel from water hyacinth and to discuss technical, socio-economic, and environmental benefits of small scale biofuels such as improving energy access, creating additional sources and means for income generation and mitigating environmental pollution at both local and global levels.

Key words: Biodiesel, Non-renewable resources, vegetable and animal oils, water hyacinth (*Eicchornia crassipes*)

I. INTRODUCTION

Biodiesel is a liquid biofuel obtained by chemical processes from vegetable oils or animal fats and an alcohol, the reaction

requires a catalyst, usually a strong base, such as sodium or potassium hydroxide, and produces new chemical compounds called methyl esters which can be used in diesel engines, alone or blended with diesel oil. ASTM International (originally known as the American Society for Testing and Materials) defines biodiesel as a mixture of long-chain monoalkylic esters from fatty acids obtained from renewable resources, to be used in diesel engines. At current production levels, biodiesel requires a subsidy to compete directly with petroleum-based fuels. Although biodiesel cannot entirely replace petroleum-based diesel fuel, there are the following advantages of biodiesel that justify its development.

Some important advantages of using biodiesel as a replacement for diesel fuel are:

- Renewable fuel, obtained from vegetable oils or animal fats.
- Low toxicity, in comparison with diesel fuel.
- Degrades more rapidly than diesel fuel, minimizing the environmental consequences of biofuel spills.
- Lower emissions of contaminants: carbon monoxide, particulate matter, polycyclic aromatic hydrocarbons, aldehydes.
- Lower health risk, due to reduced emissions of carcinogenic substances.
- No sulfur dioxide (SO₂) emissions.

- Higher flash point (100°C minimum).

II. Introduction to Biodiesel Production

Besides its lower cost, another undeniable advantage of non-edible oils for biodiesel production lies in the fact that no foodstuffs are spent to produce fuel. Due to this reason the biodiesel production trials in several countries, using non-edible oils such as castor oil, tung, cotton, jojoba and jatropha have to be led. Animal fats are also an interesting option, furthermore, highly acidic grease from cattle, pork, poultry, and fish can be used. Microalgae appear to be a very important alternative for future biodiesel production due to their very high oil yield; however, it must be taken into account that only some species are useful for biofuel production. Water hyacinth (*eichhornia crassipes*) is also one most useful feedstock for the production of biofuel. Although the properties of oils and fats used as raw materials may differ, the properties of biodiesel must be the same, complying with the requirements set by international standards.

Raw Materials for Biodiesel Production:

The raw materials for biodiesel production are vegetable oils, animal fats and short chain alcohols. The oils most used for worldwide biodiesel production are rapeseed, palm and sunflower, although other oils are also used, including peanut, linseed, safflower, used vegetable oils, and also animal fats. Methanol is the most frequently used alcohol although ethanol can also be used. Since cost is the main concern in biodiesel production and trading, the use of non-edible vegetable oils has been studied for several years with good results.

III. Biodiesel Production Process

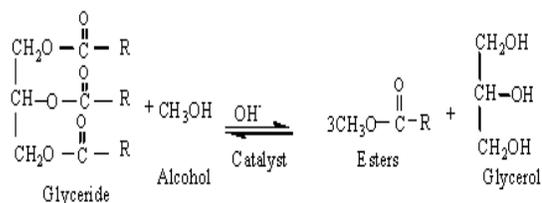
Biodiesel is produced from vegetable oils or animal fats and an alcohol, through a trans esterification reaction. This chemical reaction converts an ester (vegetable oil or animal fat) into a mixture of esters of the fatty acids that makes up the oil (or fat). Biodiesel is obtained from the purification of the mixture of fatty acid methyl esters (FAME). A catalyst is used to accelerate the reaction. According to the catalyst used, trans esterification can be basic, acidic or enzymatic.

Trans esterification reaction:

In organic chemistry, Trans esterification is the process of exchanging the organic group R" of an ester with the organic group R' of an alcohol. These reactions are often catalysed by the addition of an acid or base catalyst. The reaction can also be accomplished with the help of enzymes (biocatalysts) particularly lipases.

Animal and plant fats and oils are composed of triglycerides which are esters containing three free fatty acids and the trihydric alcohol, glycerol. In the Transesterification process, the alcohol is deprotonated with a base to make it a stronger nucleophile. ethanol or methanols are commonly used. As can be seen, the reaction has no other inputs than the triglyceride and the alcohol.

It is important to note that the acid or base are not consumed by the Transesterification reaction, thus they are not reactants, but catalysts. Common catalysts for transesterification include sodium hydroxide, potassium hydroxide, and sodium methoxide.



Water hyacinth (*eichhornia crassipes*):

Water Hyacinth (*Eichhornia crassipes* Martius) is a monocotyledonous freshwater aquatic plant, belonging to the family Pontederiaceae, related to the lily family (Liliaceae) and is a native of Brazil and Ecuador region. It is also a well known ornamental aquatic plants found in water gardens and aquariums, bears beautiful blue to lilac colored flowers along with their round to oblong curved leaves and waxy coated petioles. It grows from a few inches to about a meter in height. The stem and leaves contain air filled sacs, which help them to stay afloat in water. Water hyacinth is an aquatic plant which can live and reproduce, floating freely on the surface of fresh waters. Its rate of proliferation under certain circumstances is extremely rapid and it can spread to cause infestations over large areas of water causing practical problems for marine transportation, fishing, and at intakes for hydro power and irrigation schemes. Although water hyacinth is seen in many countries as a weed, it is possible to find useful applications as the plant has a high energy and protein content. Fibre from water hyacinth can be used for a variety of applications and products, including paper, fibre board, yarn and robe, basket work, and as an energy feedstock.

Fresh plant contains 95.5% moisture, 0.04% N, 1.0% ash, 0.06% P₂O₅, 0.20% K₂O, and 3.5% organic matter. On a zero-moisture basis, it is 75.8% organic matter, 1.5% N and 24.2% ash. The ash contains proteins contain 0.72 g methionine, 4.72 g phenylalanine, 4.32 g threonine, 5.34 g lysine, 4.32 g isoleucine, 0.27 g valine and 7.2 g leucine. Nutritive values showed that its 100 g crude contains 13.1% of crude proteins, 18.2% crude fibres, 15.3% ash, 2.16% Ca and 0.41% P.

Biological Attributes of Water Hyacinth for an efficient bioenergy crop attributes of an ideal biofuel crop are:

1. Naturally grown vegetation, preferably perennials.
2. High cellulose with low lignin content per unit volume of dry matter.
3. Easily degradable.
4. Should not compete with arable crop plants for space, light and nutrients.
5. Resists pests, insects and disease.
6. Not prone to genetic pollution by cross breeding with cultivated food crops.

Water hyacinth is low in lignin content (10%) and contains high amounts of cellulose (20%) and hemicellulose (33%). A typical biomass from land plants can have 30-50% cellulose, 20-40% hemicellulose and 15-30% lignins. In plants, lignin (composed of phenylpropanoid groups) acts as a polymer around the hemicellulose microfibrils, binding the cellulose molecules together and protecting them against chemical degradation. Lignin cannot be converted into sugars. Thus, it is not practical in biofuel production. Their degradation is a high energy process. Water hyacinth has low lignin, which means the cellulose and hemicellulose are more easily converted to fermentable sugar thus resulting in enormous amount of utilizable biomass for the biofuel industry. A new method of extracting ethanol by saccharification with diluted sulfuric acid, and hastening the process by using yeast was also developed. Further, water hyacinth grows at a very rapid pace and contains very high nitrogen content.

The biomass can be used to produce biogas and the byproducts can be used as organic manure or for producing bioethanol by further decomposition of fermentable saccharides. Water hyacinth contains large quantity of cellulose that can be converted into bioethanol by enzymes. Digestion of

water hyacinth biomass into methane anaerobically under mild conditions of pressure and temperature is possible. Thermal gasification of biomass is possible at much higher temperatures ($> 500^{\circ}\text{C}$) and takes advantage of an equally complex series of chemical reactions that occur between carbon-containing compounds, water and oxygen.

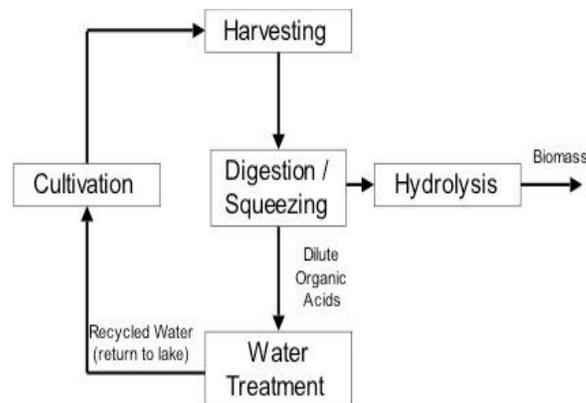
IV. Feedstock Evaluation

Because of the following characteristics of water hyacinth, it can be extensively used as a feed stock for generating biodiesel.

- Ideal Attributes
- Wide availability
- Ease of cultivation
- Frequent harvest cycles
- No / low competition with food crops
- Easy to process
- Inexpensive
- Global invasive nuisance weed
- Aquatic plant
- Low-tech processing
- Millions of dollars spent each year to remove / dispose

V. Process Description

Hyacinth was collected from unused commercial ponds or lakes, cutted in to slice mats and pressed them to remove approximately 97% water, that further can be treated with dilute acids to get biomass which is processed for transesterification reaction.



VI. Conclusion

Tremendous progress has been made technologically in the last few years in the area of biofuel production, fuelled by ever increasing price and shortage of fossil fuel. There are also concerns about global climate change and severe food shortage. Biomass is the least expensive and most globally available resource. Therefore, priority should be shifted towards utilizing biomass, leaving aside food for human consumption. The use of Water hyacinth biomass surplus of water hyacinth is appropriate due to

- Minor energy investment for cropping.
- Little trace gas emission footprints for biomass cropping and processing (mitigation of land-use and fossil trace gas emissions for energy, pesticides, herbicides and fertilizers).

Assuming conservatively that a significant amount of this material would biogenically result in methane emissions, its use as biofuels would simply be a better use for a common atmospheric emission of biogenic methane. Water hyacinth has become a serious environmental issue due to its high (vegetative and sexual) reproduction rate and dispersion. Alternatively, the high reproduction rate, nutrient uptake, and biomass yields made water hyacinth an

interesting solution for wastewater treatment and biogas production. Water hyacinth has long been seen as an invasive species all over the globe and considerable amount of resources have been spent for their control. However, they have certain qualities which can be utilized to produce biofuels (both bioethanol to power vehicles and motors, biogas to generate electricity) as the plants are low in lignin content and have rapid growth rate. Basing on all the above facts, the Water hyacinth (*Eichhornia crassipes*) can be considered as a good tool for cheap industrial production of biofuels.

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