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POTENTIAL OF BIODIESEL PRODUCTION IN THE UNITED ARAB EMIRATES BASED ON THE LOCALLY AVAILABLE FEEDSTOCK

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ABSTRACT

This paper outlines the potential for biodiesel production in the United Arab Emirates (UAE) and discusses locally available feedstock. With a growing global demand for renewable energy sources and sustainable practises, the UAE, like many other countries, is attempting to lessen its reliance on fossil fuels. As a promising renewable resource, biomass provides a possibility for biodiesel production, contributing to the country's long-term energy and sustainability goals. Statistics related to feedstock available in UAE are discussed along with some experimental and modelling studies related to biodiesel production in the UAE. In addition, existing biodiesel production companies in the UAE, such as Lootah Biofuels and Neutral Fuels, and their contributions in helping the UAE reach its sustainability goals are showcased. Finally, future research areas related to biodiesel production and possible feedstock are discussed.

Keywords: biomass, biodiesel, United Arab Emirates, feedstock, transesterification, biodiesel production companies.

1 INTRODUCTION:

Renewable energy has a crucial role in meeting the world's growing energy demands while addressing environmental issues such as climate change and air pollution [1]. In contrast to fossil fuels, which contribute to greenhouse gas emissions, renewable energy sources are naturally replenished and produce little to no emissions during energy production [2][3]. These sources capture energy from natural processes and may be used to generate power and heat residences. Renewable energy sources include solar [4], wind [5], geothermal [5], ocean thermal energy [6], biomass [7], etc.

Biomass is an abundant resource that may be found worldwide. As per numerous studies, global biomass land resources are estimated to be roughly 1,800 billion tonnes, while marine biomass resources are estimated to be around 4 billion tonnes. Biomass energy is available on

a global scale and has an approximate energy output capacity of 33,000 EJ. Despite this, biomass resources are only used to a limited extent, accounting for around 14% of global main energy usage [8]. Biomass conversion involves numerous techniques for using biomass resources sustainably. Biomass conversion may involve effective biomass collection, replanting, sustainable farming methods, and promoting responsible land management to conserve biomass resources for future generations. These techniques include biomass gasification, combustion, anaerobic digestion, pyrolysis, biomass cogeneration [9], and transesterification.

Correspondingly, biodiesel is an environmentally favourable alternative to conventional diesel fuel. Transesterification is one of the main techniques that is used to produce biodiesel from sustainable feedstocks such as vegetable oils, animal fats, or leftover cooking oils [10]. Using alcohol and a catalyst, the triglycerides in the feedstock are transformed into biodiesel and glycerol in the chemical process of transesterification [11]. Because it is manufactured from carbon-neutral or low-carbon sources, biodiesel has the potential to significantly reduce greenhouse gas emissions when compared to traditional diesel [12]. Furthermore, biodiesel may be mixed in various amounts with petroleum-based diesel, making it compatible with current diesel engines and infrastructure [13][14].

Keywords are a direct reflection of an author's objectives in scientific research. The dataset was input into VOSviewer using a keyword mapping feature to find the most relevant keywords in biodiesel production from 2010-2023. **Figure 1** shows the most relevant keywords in the biodiesel production field. From **Figure 1**, transesterification process is mentioned many times as well as several feedstocks such as oils and fats. The use of catalysts enhances the efficiency and effectiveness of the reaction. Furthermore, the terms “nonhuman” and “algae” indicate that many researchers have investigated different feedstocks for biodiesel production.

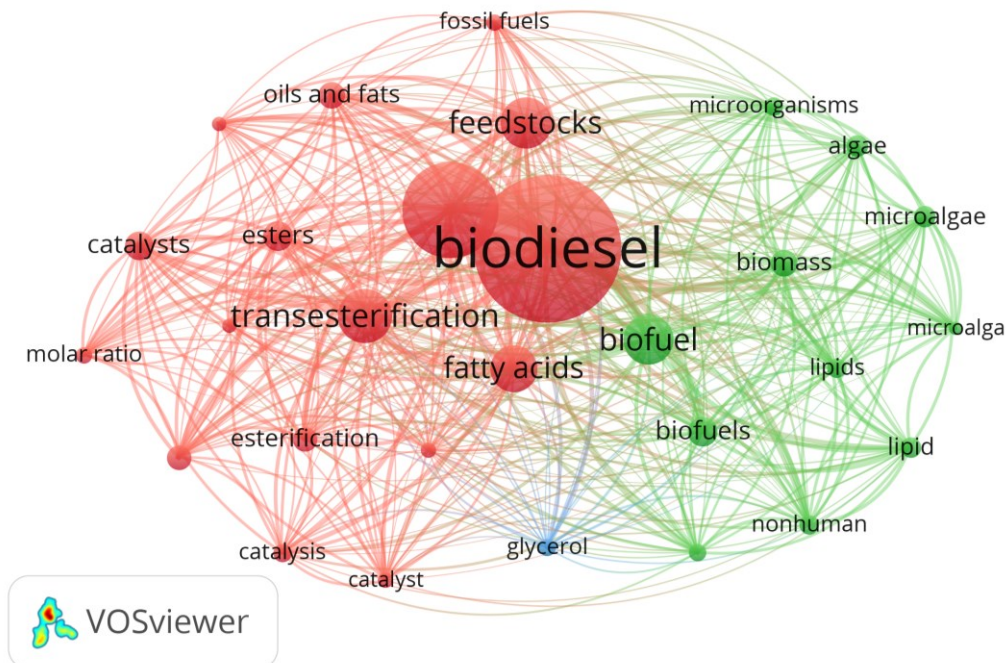


Figure 1: Keywords Intensity in Biodiesel field.



The United Arab Emirates (UAE) has unique and numerous types of biomass resources due to its unique geographical qualities. The UAE has an abundance of seagrasses and macroalgae throughout its 650-kilometer coastline, which can serve as significant biomass sources [15]. Furthermore, date palm, a staple crop in Arab countries, is especially important in the UAE. In this region, date palm leaf waste alone may provide approximately 2 million tons of lignocellulosic feedstock annually. According to some of the relatively recent data from the United Nations Food and Agriculture Organisation, the UAE produced more than 345,000 tonnes of dates in 2018, a 44% increase from the production in 2011 [16]. Aside from date palm waste, the UAE creates about 1.79 million tons of agricultural waste per year, excluding date palm leftovers [15]. The UAE also generates a significant volume of municipal solid waste per capita daily, providing a potential resource for biofuel generation. One of the UAE's key agricultural operations is livestock activities, emphasizing the need to research applications for manure from camels, sheep, goats, and cattle. These various biomass resources offer significant prospects for sustainable energy generation and resource usage in the UAE, coinciding with larger initiatives to improve environmental sustainability and energy security [15].

This paper sheds light on some of the locally available feedstock in UAE and the existing biodiesel production companies along with their services and role in making energy production greener and cleaner. Some of the studies related to biodiesel production in UAE as well as some future directions in research are summarised to help offer researchers insights on the current status of literature and possible research development areas.

2 RELEVANT STUDIES ON BIODIESEL PRODUCTION IN UAE

One of the main focuses in the UAE is on the feasibility and sustainability of biodiesel production, considering its unique environmental and economic context. These studies investigated different feedstocks for biodiesel production. The development and adoption of biodiesel technologies in the UAE are also driven by collaborative initiatives between academic institutions and governmental organizations, which align with the nation's commitment to sustainability. Hussain et. al [17] investigated the cost-effectiveness of producing biodiesel from waste cooking oil in the United Arab Emirates. The study analysed 7 different scenarios, varying the production method between conventional and sonication, with some scenarios considering oil incentives and/or subsidies, to forecast profits and other financial values for large-scale biodiesel production. Survey results showed that restaurants resulted in more than five times more oil compared to the residential segment, with sunflower oil dominating the residential sector and corn oil dominating restaurants. The economic study revealed that profits for all scenarios only started from the second year of operation and adding sonication equipment increased capital and operating expenditures in some scenarios, but the increased production volume and reduced process time made it economically beneficial. The net present value calculation was used to conclude how profitable the project is, with a 4% discount rate and a project lifetime of 15 years. The government subsidy was a major parameter in deciding the financial feasibility. One of the main conclusions of the study was that large-scale production using sonication and without oil incentive was the best scenario for the UAE in terms of economic feasibility and administration.

Other studies focused on the optimization of the process of biodiesel production. For instance, Inayat et. al [18] investigated the usage of potassium hydroxide on activated carbon as a catalyst for the transesterification of local neem oil. RSM tool was utilized to obtain the

optimum process parameters including time, catalyst concentration, as well as methanol-to-oil ratio. The highest proportion of biodiesel (100 wt%) was produced at 6:1 methanol-to-oil ratio, 0.5 wt% catalyst, and 60 minutes duration.

Also, using waste cooking oil and a catalyst made of silicon dioxide and calcium oxide derived from glass and animal bone waste, Asaad et. al [19] performed transesterification and optimization processes. The highest biodiesel production was found to be 92.34% utilizing a methanol-to-oil ratio of 14.83:1, catalyst concentration of 3.11 wt%, and a duration of 143 minutes after the parameters were optimized with the help of response surface methodology (RSM). The yield of 92.14% was obtained experimentally, for the run using a 13:1 methanol-to-oil ratio, 2 wt% catalyst, for 150 minutes, which closely matched the RSM results.

In a study by Kamil et. al [20], investigation into the optimal production parameters for producing biodiesel from date seed oil was conducted. Four different biodiesel blends (5%, 10%, 15%, and 20%) were prepared and tests were conducted using a compression ignition engine. These tests involved varying engine speeds from 1,600 to 3,600 rpm and using engine loads of 50%, 75%, and 100%. The results showed that the maximum oil yield obtained was 10.74 wt.% and biodiesel conversion rate was 92%. The properties of the biodiesel met the required standards, and the brake power, brake thermal efficiency, and brake specific fuel consumption were comparable to those of conventional diesel, however, the conventional diesel was somewhat superior. Additionally, all blends resulted in lesser carbon dioxide, carbon monoxide, and hydrocarbon emissions but higher levels of nitrogen oxide emissions. The study concluded that date seeds have the potential to be a viable feedstock for biodiesel production and warrant further research in this area.

Table 1: Studies on biodiesel production in the UAE.

Feedstock	Catalyst	Production Process	Summary	Biodiesel Yield	Reference
Waste Cooking oil	NaOH	Conventional/ Sonication	Economic feasibility of biodiesel production in the UAE was studied.	N/A (assumed)	[17]
Neem oil	KOH with activated carbon	Transesterification	Production and optimization of biodiesel production were performed.	100%	[18]
Waste Cooking oil	Glass and animal bones (CaO SiO ₂)	Transesterification	Production and optimization of biodiesel production were performed.	92.3419%	[19]
Date seeds	NaOH	Transesterification	Testing of biodiesel blends in a CI engine was carried out.	92%	[20]

3 BIODIESEL PRODUCTION COMPANIES IN UAE

With the growing interest in sustainable and green fuels over the recent years, a number of pioneering biodiesel enterprises have emerged in the country. One of these companies is Lootah Biofuels, which was founded in 2010 in Dubai with the objective of introducing and

inventing sustainable solutions for long-term energy needs by significantly increasing production capacity, consolidating distribution networks, and refining biodiesel quality. Lootah Biofuels has provided a practical alternative for producing biodiesel from used cooking oil. They are considered one of the largest authorised used cooking oil collectors by Dubai Municipality and have their own fuel outlets. Used cooking oil is collected from various restaurants and the providers are paid, which incentivizes suppliers while assisting the municipality in safe disposal of the waste oil by successfully turning it into biofuel. Currently, Lootah Biofuels has fuel outlets in Dubai and Sharjah, and soon in Abu Dhabi. The products provided by the company in addition to the current statistics of the number of outlets, recycling facilities, production amount, and amount of carbon dioxide reduction are shown in **Figure 2** [21]. The amount of biodiesel produced monthly at the Dubai Industrial city factory is approximately 106,000 litres and the amount of biodiesel from one liter of waste oil is 920 ml, while the time needed for a complete cycle of production is one day. To produce biodiesel using 1,000 liters of oil, 1.1904 units of electricity, 31 liters of water, and 26.275 liters of diesel are required [22].

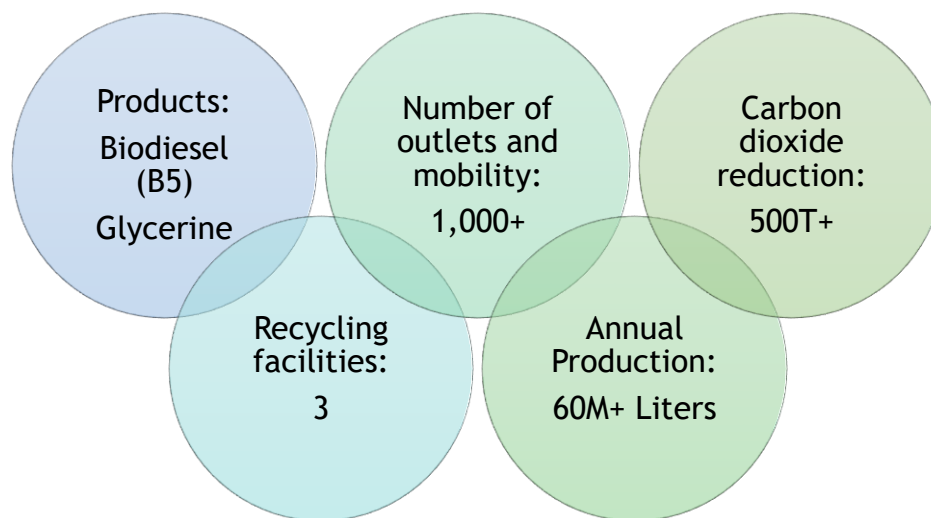


Figure 2: Lootah Biofuels Products and Statistics.

Neutral fuels is another company that produces biodiesel from used cooking oil that is collected from Dubai and Abu Dhabi through their convenient collection service called iCollect service. This helps hotels and restaurants achieve their sustainability objectives while saving money [23]. McDonald's UAE's logistics fleet has been running on biofuel produced by Neutral fuels using leftover vegetable oil from its UAE restaurants since July 2011. Additionally, Dubai's Diamond Developers has chosen B100 biodiesel from Neutral fuels to power the development of the new buildings in Dubai Sustainable City's Phase 2. In this case, the renewable fuel alternative is made from used cooking oil consumed by restaurants in the master community's community plaza, allowing the Sustainable City to reduce its carbon footprint by up to 150 tonnes of CO₂ per year during the construction period [24].

BiOD Technology FZE has a capacity of 60,000 Mt annually in UAE and India. The company's strategy in producing biofuels helps to address some of the oldest difficulties resulting from improper disposal of waste cooking oil, animal fats, sewage sludge, grease tap leftovers, and so on. The BiOD Technology has developed a technique for producing biodiesel from renewable biomass-based raw feedstock such as tallow, acid oils, and so forth [25].



4 FUTURE RESEARCH AND DEVELOPMENT AREAS

The catalysts utilized in the biodiesel production process are a crucial aspect in improving the process efficiency, sustainability, and cost. For instance, since chemical catalysts may harm the environment, additional research into biocatalysts is needed. The sustainability of catalysts is also crucial, which means that catalysts formed from biological, industrial, and agricultural wastes can be reused and disposed of responsibly. According to many publications, the lipase enzyme is an excellent biocatalyst in biodiesel production, and once completely optimised for optimal yield, it can be employed commercially [26]. Additionally, the cost of fuel produced from biomass can be higher than that of fossil-fuel-derived fuel. From a thermodynamic standpoint, integration and heat waste reduction would improve energy output compared to the consumed energy, narrowing the gap between renewable energy fuels and fossil-based ones. A good approach would be to create a biorefinery design that can produce many fuels through various processes. The integration of the different biomass conversion processes increases the energy utilization. Finally, the utilization of feedstock such as waste dates which exist in great quantities in the UAE is crucial for this region [16]. Biodiesel production from microalgae in the UAE has yet to be commercialised, even though the biodiesel yield of microalgal lipids is higher than that of waste cooking oil, which is commonly used, due to the high amount of free fatty acids in the waste oil possibly resulting in the reduction of the biodiesel yield due to saponification [27]. The exploration and testing of new unutilized feedstock for the production of biodiesel is necessary.

5 CONCLUSION

In conclusion, this paper has explored the current status of biodiesel production in the United Arab Emirates (UAE) as well as available feedstocks. It has highlighted the role of existing biodiesel production companies in encouraging greener and cleaner energy production in the country, and it was shown that a number of biodiesel companies are emerging with the increased interest in sustainable and environmentally friendly fuels. Additionally, the paper has summarized significant studies related to biodiesel production in the UAE including factors like the type of catalysts and feedstock used, yield when applicable, and production process. Some of the main aims of biodiesel related research is the optimization of the biodiesel production process and conducting feasibility studies to study the potential and profitability of biodiesel plants. Future research directions or areas of development were outlined which offers researchers valuable insights into the current research status and potential future ideas for further research.

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