Assessment of Sustainable Biodiesel Feedstock in Rajasthan

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Abstract:- Biodiesel is being explored as prospective alternate for conventional high pollutant fuels obtained from crude oils. The use of biodiesel will not only reduce the burden on the foreign exchange by reducing the imports of oil, but will also be a less polluting renewable sources of energy for the protection of the environment and fulfilling the future energy needs. The use of biodiesel has grown considerably during last few years.
Rajasthan is a largest state of India and huge wasteland area is available for plantation of biodiesel feedstock. In the present paper attempted has been made to assess the potential of sustainable biodiesel feedstock and production of biodiesel in Rajasthan.

Keywords *: Biodiesel, Vegetable Oil, Waste Land, Plantation.*

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I. Introduction

Petroleum fuels which are extracted from crude oils are the primary source of energy for sustainable development of any country and the demand for petroleum-based fuel is increasing with alarming rate. The increase in energy demand is expected to continue due to increasing industrialization, increasing number of automobiles, increasing standard of living and expanding population. In India the consumption of diesel fuel is projected to grow from 66.9 Mt in 2011-12 to 79.8 Mt in 2015-16 and the demand for diesel fuel has been estimated to be 83 Mt in 2016-17. Table 1 shows the Demand of diesel in India.

Rapid increase of fuel prices, shortage of conventional fuels and depleting petroleum fuel reserves have forced us to look for alternative fuels which can meet the ever increasing demand of energy. Development of biodiesel as an renewable alternative source of energy for mechanized, industrial, agricultural and transport sector has become critical in the national effort towards maximum self-reliance. Biodiesel has been a possible substitute or extender for conventional diesel and the prospects for biodiesel is very promising in the short term because of their availability and sustainability.

Biodiesel is defined as the Monoalkyl esters of long chain fatty acids for use in Compression Ignition engines. It can be derived from vegetable oils (both edible and non edible) like sunflower oil, used frying oil, jatropha oil, karanja (pongamia) oil, jojoba oil, castor oil, soybean oil, kusum oil, mahua oil, neem, thumba oil etc. Biodiesel has physical properties vary similar to conventional diesel. Comparison of properties of diesel with biodiesel derived from Jatropha oil and karanja oil is shown in table 2.

Year	Diesel Demand in India (Mt)
2011-2012	66.9
2012-2013	69.4
2013-2014	73.2
2014-2015	76.1
2015-2016	79.8

Table 1 Demand of Diesel in India

S.N	Properties	Diesel	Biodiesel from Jatropha oil	Biodiesel from Karanja oil	Biodiesel from Thumba oil
1	Density (gm/ml at 25°C)	0.80 - 0.84	0.88	0.899	0.889
2	Calorific value (MJ/Kg)	42.63	38.45	36.72	39.37
3	Cetane index	45-55	51	50	52
4	Viscosity (cst at 25°C)	4.5	5.65	5.58	5.86
5	Flash point (°C)	61°C	170°C	167°C	174 °C
6	Fire point (°C)	69°C	179°C	173°C	184°C

Table 2 Comparison of Properties of Biodiesel and Diesel

Biodiesel is a clean burning, efficient, natural energy alternative to diesel fuel. Among the many advantages of biodiesel fuel includes, safe for use in all conventional diesel engines, non-flammable and non-toxic, offers almost the same performance and engine durability as petroleum diesel fuel, reduces tailpipe emissions, visible smoke and noxious fumes and odors. The use of biodiesel results in substantial reduction of unburnt hydrocarbons, carbon monoxide and particulate matters. It is considered to have almost no sulphur, no aromatics and its higher cetane number improves the combustion quality. As a renewable source of energy biodiesel has a favorable impact on the environment, they can replace fossil fuels for use in engines. Extensive utilization of biodiesel can reduce the dependence on petroleum, which is currently the main source of energy for the world. For countries without or limited petroleum reserves, the use of biodiesel can lead to reduce imports of petroleum-based fuels, thus resulting in significant foreign exchange savings.

Use of edible oils like soybean, sunflower oil, coconut oil to produce biodiesel in India is not feasible as these oils are being consumed as food and there is a big gap in demand and supply in the country. So in Indian conditions only non-edible oil seed plants such as jatropha, karanja, castor, jojoba, kusum, thumba etc. can be considered for biodiesel production.

II. Biodiesel Production – Transesterification of Vegetable Oils

Biodiesel is produced from vegetable oils by converting the tryglyceride oils to methyl ester with a process known as transterification. The process of transterification converts the large tryglyceride to smaller esters, which have molecule size comparable to that of petrodiesel. Tryglyceride are readily transterified batch wise in the presence of alkaline catalyst at a atmospheric pressure and at 60-70°C with an excess of methanol. The mixture at the end of reaction is allowed to settle. The lower glycerin layer is drawn off while, the upper methyl ester layer is washed to remove-entrained glycerin. The excess methanol is recovered in the condenser, sent to a rectifying column for purification. Transterification process for biodiesel production is illustrated in fig 1.

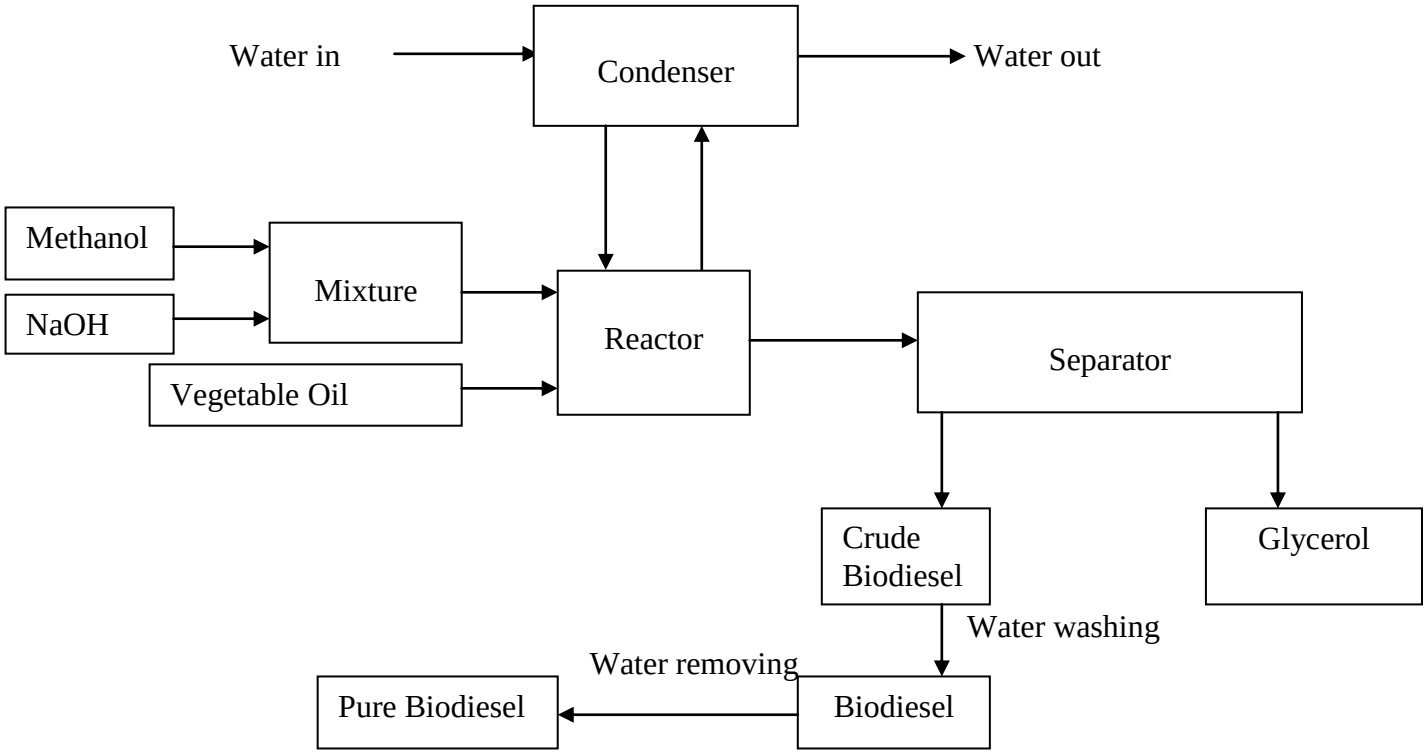
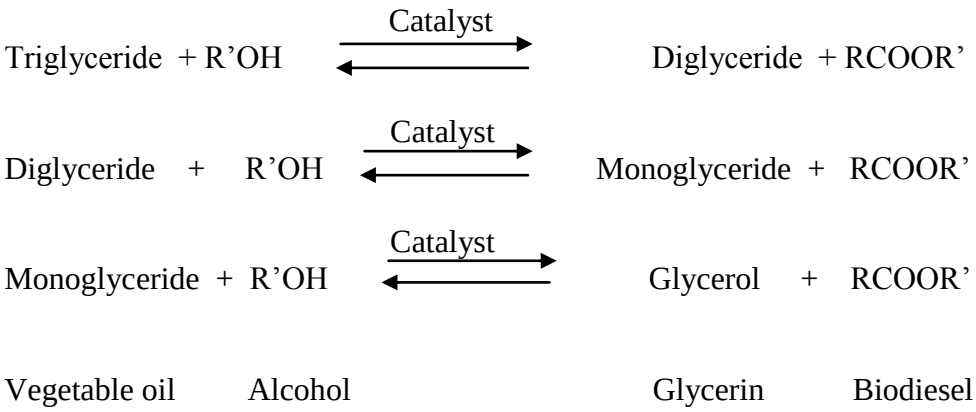


Fig.1 Transterification process for biodiesel production

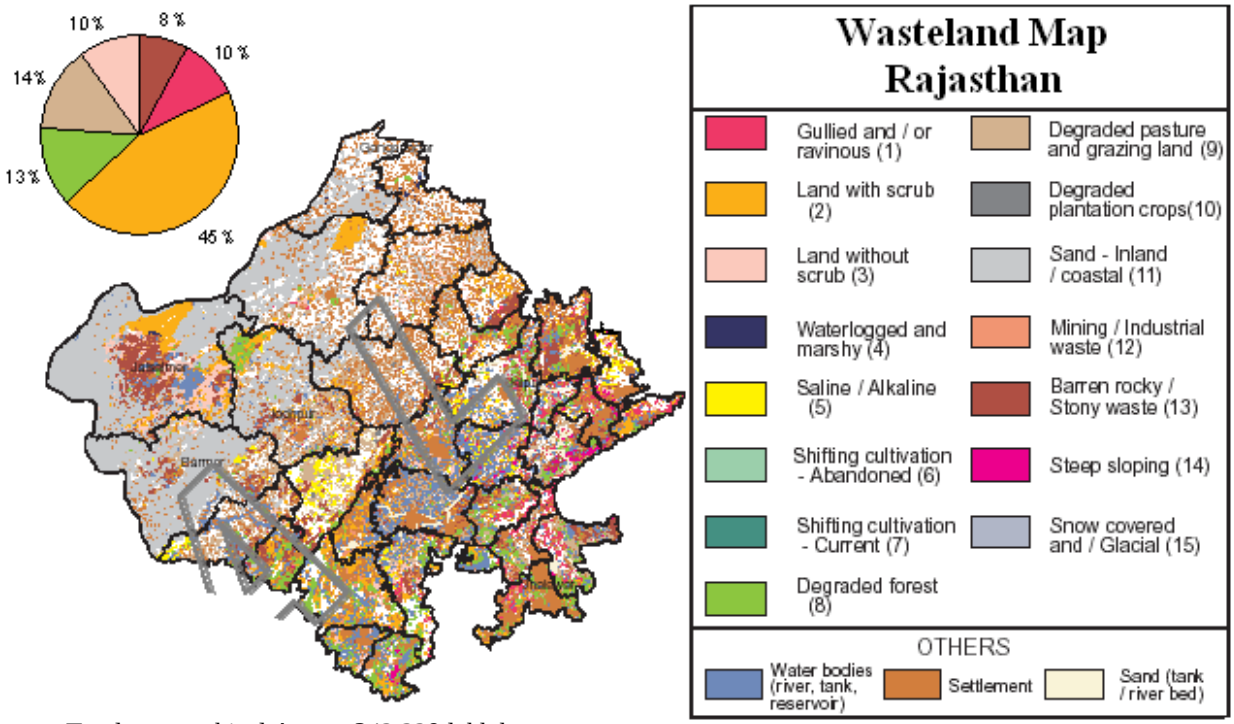
The mechanism of transterification is described as follows.



III. Climatic Conditions and Land Availability for Cultivation of Biodiesel Feedstock in Rajasthan

Rajasthan lies on the western part of India mostly in the tropical zone. The state has between 23˚3' N to 30˚12' N latitudes and from 69˚30' E to 78˚17' E longitudes. Rajasthan has a hot, dry and desert climate. The average yearly rainfall of the state is 52 cm, most of which fall in the rainy months from July to September. The most of the year the temperature is high and the air has low humidity. On average winter temperature range from 5 to 28˚C and summer temperature range from 25 to 48˚C. Due to less rainfall and dry climate, Rajasthan has lack of forests and natural vegetation.

Rajasthan is the biggest state of India and having the geographical area 342.229 lakh hectares and out of which total wasteland is 101.454 lakh hectares which is around 29.64% of total geographical area. Rajasthan covers more then 10% of India's total land mass. Map 1 shows the wasteland availability in Rajasthan, which can be utilized for cultivation of biodiesel feedstock.



Total geographical Area	342.229 lakh hectares
Total wasteland area	101.454 lakh hectares
Wasteland area	29.64%

Map 1 wasteland availability in Rajasthan

IV. Potential Feedstock for Production of Biodiesel in Rajasthan

There are many tree species, which have been found most promising and very suitable for biodiesel production in adverse climatic conditions of Rajasthan. Among the many species which can yield oils as a sources of energy in the from of biodiesel, jatropha and karanja have been found to be the most suitable species for biodiesel production in Rajasthan due to their various favorable attributing life, their hardy nature, high oil recovery and quality of oil etc. These plants can be planted on degraded lands, farmer's fields boundaries, fellow lands, wastelands and other lands such as along with railway tracks, roads and irrigation canals etc. The jatropha and karanja plants can grow under unfavorable climatic conditions of Rajasthan because of their low moisture demand and tolerance to high temperature. They are well adopted in arid and semi-arid conditions and can be grown on wastelands. Biodiesel production from large-scale cultivation of these selected plants on wastelands can replace diesel fuel even up to 100% level. Cultivation and climatic condition required for the plantation, properties and uses of jatropha and karanja plants are discussed below.

Jatropha plant

Jatropha is versatile plant with several uses. The oil from the seeds can replace or substitute diesel fuel. Jatropha belongs to the family Euphorbiaceae. It is a large shrub or tree with thick branches and number of large leaves attains height of 3-4 meters in 3 years. The oil content of the seed range between 33-40%. Each seed is about 2 cm (3/4 inch) long. The plant starts giving seed in a period of one to two years after planting but reaches to the maximum productivity level after 4-5 years. At yellow stage, the fruits are harvested. The fruits are allowed to ripe and fall to ground or being harvested by plucking. The cleaned seeds are decorticated prior to pressing or expelling. The oil extraction can be done with engine driven expellers. These are simple machines, which can be operated at village level and built within the country. Jatropha plants can be grown on waste and other lands such as along the canals, roads, railways tracks, on borders of farmer's field as boundary fence or live hedge in the arid/semi-arid areas and even on alkaline soils. The plant density is supposed to be of 2500 per hectare (spacing of 2 x 2 meters) and the best planting time is 1 to 2 months before the beginning of the rainy season. Jatropha seed germinates with in 30-120 days.

Karanja Plant

The Karanja is a medium size tree, may be planted at density of 1111 plants per hectare with the spacing of 3 x 3 m. It can be regenerated through shoot cutting, trans planting and direct sowing. The tree bears green pods which after some 10 months change to a tan colour. The pods are flat to elliptic, 5-7 cm long and contain 1 or 2 kidney shaped brownish red kernels. The yield of kernels per tree is reported between 8 and 24 kg. The kernels are white and covered by a thin reddish skin. The composition of typical air-dried kernels is; Moisture 19%, Oil 27.5% and Protein 17.4%. The oil content varies from 27 to 39%. The oil contains toxic flavonoids including 1.25% karanjin and 0.85% pongamol. After refining, and removal of these flavonoids, the oil still produced retarded growth in rat feeding studies. The karanja oil is used as alternative fuel for diesel engines, as lighting oil and for making shop etc. Soap made from crude oil tends to darken due to a component, Isolonchocarpin, which gives a wine red colour in the presence of alkali. In rural areas the leaves are used to prevent infestation of grains. The cake after oil extraction may be used as manure.

Thumba Plant

Thumba Plans (Citrullus colocynthis) is known as Indrayan in Hindi and Bitter Apple in English, is a native of Turkey and also found in many parts of Asia and Africa. In India it mainly grows in all parts of Rajasthan and Gujarat. The plant is in the form of a creeper and grows well in sandy soil. It grows along with main crop of Bajra and hence does not require any special care. The oil of this plant is locally called as thumba oil. Citrullus colocynthis, that grows as a creeper in sandy soil within a six month crop cycle has enormous potential for biodiesel production. Presently, the plant is mainly used as cattle feed by farmers and raw thumba oil is also consumed in large quantities by the local soap industries. It is also used as a laxative and anti-inflammatory drug. Thumba seed oils can be used as diesel engine fuel as well as a sustainable source of renewable energy for biodiesel production.

5. Government Policy for Cultivation of Biodiesel Feedstock in Rajasthan

After enacting legislation on contract farming, Rajasthan government is providing facility of leasing out of degraded land and wasteland including ravines, ranging from 500 hectares to 20,000 hectares to private parties for agro-based produce purposes.

6. Conclusions

The specific research in the area of cultivation of biodiesel feedstock in less fertile area will provide satisfactory answer to double challenge of energy crises and forced deforestation in semi-arid and arid region of Rajasthan. Large-scale biodiesel production will make it possible to supply part of the increasing demand for primary energy. The significant points emerged from the projections and discussions are ;

- Rajasthan has a great potential for biodiesel production as there is large mass of wasteland is available for cultivation of biodiesel feedstock such as jatropha, karanja and thumba plants.
- Large quantity of biodiesel production is feasible in Rajasthan.
- Large scale biodiesel production would give multiple benefits like employment generation for rural people, reduction in the deforestation rate and more productive use of wasteland, reduction in pollution, improvement in environment through erosion control and reduction in the expenditure of imports of petroleum fuel etc.
- Considerable attention has to be paid to enhance cultivation of biodiesel feedstock and biodiesel production in Rajasthan to meet increasing energy demand.

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