BIO-DIESEL: AN ECO-FRIENDLY SUSTAINABLE FUEL SOURCE

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INTRODUCTION

Fuel is an essential requirement in our daily life. It occurs in three physical forms – solid, liquid and gas. Liquid fuels include petro-bio-fuels. Petro–fuels are fossil fuels. These have been the primary sources of energy for transportation and industrial sectors. But, these fuels are non-renewable. Increasing trends of consumption of these fuels would soon result in the depletion of reserves. As India is importing large reserves of crude petroleum, it would face economic catastrophe in the event of shortage of this natural fuel source. In view of this, the alternative renewable resources assume high importance not only in terms of rescuing the national economy and developmental activities but also in the context of reducing pollution. The best option is biofuel, which comes from different biological materials. This paper provides some inputs to show the importance of bio-fuels to combat pollution problems and solve fuel crisis.

PETRO-FUELS

Petroleum is the crude oil, which is a non-renewable resoure mostly, imported from the Gulf countries. Among petro-fuels, diesel is an important automotive fuel in the world. Diesel has 80% of share in liquid fuel consumption in transport sector in India. Its advantage lies in its larger energy

density but has some ease of use and control of flow as that of a gaseous fuel and unlike solid fuel, which has a large inert material and leaves the technical problem of ash disposal. The disadvantages include production of soot, ammonium, nitrates, elemental carbon condensed organic compounds, carcinogenic compounds and heavy metals –arsenic, selenium, cadmium and zinc. Soot particles absorb major pollen allergens, enhance *in vivo* antibody production and induce lung cancer. Exposure to diesel exhaust causes well defined marked systematic pulmonary inflammatory responses in humans (Tiwary 2004).

BIO-FUELS

Bio-fuels are biodegradable, non-toxic and essentially free of sulphur and aromatics. They are produced from biomass feed stocks, as a by product from the industrial processing of agricultural or food products, and from the recovery and reprocessing of products like cooking and vegetable oil. They contain no petroleum, but can be blended at any level with petroleum to produce bio-fuel blends. India has great potential for the production of bio-fuels like bio-ethanol and bio-diesel from non-edible oil seeds.

BIO-DIESEL

Bio-diesel is a fatty acid of ethyl or methyl ester made from virgin or used vegetable oils (edible and non-edible) and animal fats; it is a renewable source. The raw oil is subjected to a chemical process “trans-esterification” in which the oil is reacted with an alcohol (methanol or ethanol) in the presence of a catalyst such as sodium hydroxide to produce methyl or ethyl ester and glycerol. The methyl or ethyl ester formed in the process

constitutes “bio-diesel”. Glycerol or glycerine is the byproduct, which also has commercial value. One hundred kg of crude oil, 24 kg of methanol and 2.5 kg of Sodium hydroxide produce 100 kg of bio-diesel plus 26 kg of glycerine. For each ton of bio-diesel, 100 kg of crude glycerine is simultaneously produced in the process (Kumar et al. 2004). The residual crushed seed, known as de-oiled cake, is a good source of manure. Seed husk is useful to make packaging materials.

The sources of bio-diesel are quite diverse in India. The plant sources include *Euphorbia antisyphilytica, E. tirucalli, Excoecaria agallocha, Hevea brasiliensis, Jatropha curcas, J. gossypifolia, Ricinus communis* (Euphorbiaceae), *Calotropis gigantea, C. procera* (Asclepiadaceae), *Madhuca indica* (Sapotaceae), *Glycine max, Pongamia pinnata* (Fabaceae), *Albizzia chinensis* (Mimosaceae), *Avicennia marina* (Avicenniaceae), *Ceriops decandra*(Rhizophoraceae), *Azadirachta indica* (Meliaceae), *Calophyllum inophyllum* (Clusiaceae), *Helianthus annuus* (Asteraceae), *Brassica napus, B. rapa* (Brassicaceae), *Cocos nucifera* (Palmaceae) *and Cannabis sativa* (Cannabaceae). In addition to these, recycled cooking vegetable oils from restaurants, beef tallow (fat) and fish oil are also potential sources for bio-diesel production.

Of these different sources, the most promising species for bio-diesel production include *Jatropha curcas* (Euphorbiaceae) and *Pongamia pinnata* (Fabaceae). The details of these two plant species are provided from the commercial point of view.

JATROPHA CURCAS

It is a woody shrub or small tree. It is native to Latin America and related very closely to the Castor plant, *Ricinus communis*. The plant flourishes well in different climatic zones in the tropical world. It requires moderate rainfall and soil fertility. Its leaves are not edible to animals; used as fencing to crop fields/house premises. It is a fast growing plant. It propagates well by cuttings/seed; fruit production starts from second year onwards in cuttings and third year onwards in seed produced plants. It does not require large doses of fertilizer. Once planted, it produces seed crop for more than 50 years. A plant of about 7 years of age produces about 2-5 Kg seed per year with 30-35% oil content.

The flowering occurs profusely during rainy season. It produces male and female flowers in the same inflorescence. Each female flower is surrounded by a number of male flowers. The number of female flowers per plant is very low; the ratio of male to female flowers is 29:1. Both flower sexes produce nectar as a reward to pollinators. Pollen flow between male and female flowers should occur for fruit and seed set. Bees and flies mediate pollen flow between male and female flowers in the same and different individuals. Seed quality depends mostly on cross-pollination. Pollinator management is an important activity for seed set by quality and quantity. Fruit set rate is related to the number of female flowers produced by the plant. Natural fruit/seed set rate varies from 37% to 61%. Some percent of self-pollinated (geitonogamy) fruits drop off prematurely. Cross-pollinated fruits do not drop off and all develop to maturity. Fruits mature in 3 months. Each fruit produces 3 seeds, which are initially green, later yellow and finally

brown/black. Early summer season is ideal for fruit/seed collection (Solomon Raju and Ezradanam 2002).

PONGAMIA PINNATA

It is a deciduous tree species, native to the Western Ghats of India. It occurs primarily along the banks of streams and rivers, near the sea on beaches and tidal forests, and in dry places. It mines water from 10 meters depth without competing with other plants in the habitat. Its leaves are not edible to cattle. Once planted from seed, it starts to produce pod/seed crop from 5th year onwards and is expected to be reproductively active for about 100 years.

Flowering occurs during summer season. The flowers are purplish-white, bisexual and nectariferous. They have explosive floral mechanism and bees trip the mechanism causing the release and deposition of pollen on them. This finally ends up in pollination. The bees such as *Apis, Trigona, Ceratina, Pithitis, Megachile, Amegilla* and *Xylocopa* use the flowers as pollen and nectar sources. This plant is an excellent floral source for honeybees to produce honey during summer period. Bees while collecting forage trip the floral mechanism causing self or cross-pollination. Butterflies and wasps also utilize this as nectar source occasionally but have a minor role in pollination. The flowers at the end of the day close and remain so permanently; the pollinated flowers produce fruits while unpollinated flowers fall off on the 3rd day. Flower drop rate is very high. The fruit (pod) takes about one year time for maturation. Each fruit produces 1-3 seeds; 1 and 2 seeded pods are common (Solomon Raju and Rao 2005). Seeds contain 30-40% of red brown, non-drying and non-edible oil with triglycerides – pongamol and karanjin having 9,344 K.

cal/Kg. Ten trees of over 10 years of age with good pod set may produce 400 liters of oil, 1,200 kg of fertilizer grade oil cake and 2,500 kg of biomass as green manure per year. Plants cultivated from seeds produce good quality seed with much oil content.

ADVANTAGES OF BIO-DIESEL

It is a green fuel. It has 11% of oxygen, which is useful to improve combustion rate and reduce hydrocarbon emission, carbon monoxide and particulate matter in exhaust fumes. It is simple to use, biodegradable, non-toxic and essentially free of sulphur and aromatics. It has a density nearly equal to that of petro-diesel and mixes well with diesel. It is almost equal to petro-diesel in terms of the energy density. It increases the flash point, which is favourable for India with higher ambient temperature. Its promotion helps to restore degraded land over a period of time. It serves as climatic neutral in view of the climatic change that is presently an important element of energy use and development. Its production can be raised easily as per the demand for more fuel.

DISADVANTAGES OF BIO-DIESEL

Bio-diesel causes excessive carbon deposition and gum formation (polymerization) in engines and the engine oil gets contaminated and suffers from flow problem. It has relatively high viscosity than diesel and needs higher injector pressure. Stability in storage is a problem. It oxidizes into fatty acids in the presence of air and causes corrosion of fuel tank, pipe and injector. It solidifies at low temperatures, but adding additives can prevent solidification. In India, high ambient temperature exists and solidification of fuel is not an issue.

CONCLUSION

Bio-diesel is a potential alternative for non-renewable fuels. It is gaining importance in recent times in developing countries because it is bio-based, eco-friendly, biodegradable, non-toxic, renewable and sustainable fuel source. Its production is increasing in European countries. It can be mixed with ordinary diesel; it improves cetane rating and engine lubrication.

In India, Railways, Rig owners and Truck owners Associations have already expressed their commitment to use bio-diesel in place of petro-diesel. In fact, Railways have already tested the performance of bio-diesel (B 10) blend to run Lucknow-Allahabad Janshatabdi Express and B 5 blend to run Delhi-Amritsar Shatabdi Express. Mercedes Benz C 220 CDI vehicle was run in various states of the country for more than 10,000 km without any engine modification using 100% bio-diesel by CSMCRI, Bhavnagar. The Central Government has instituted a National Bio-diesel Board to promote bio-diesel production. All this shows that bio-diesel will be a potential option in view of the fossil fuel crisis.

Bio-diesel cropping systems provide income to farmers who are around the degraded land and are facing economic hardship. Farmers of good agricultural land can also benefit by planting *Jatropha* along the boundary of their fields. *Jatropha* is not a large plant that can obstruct air or sun to the main crop. In addition, being non-edible, it will protect the main crop from the stray animals. *Pongamia* is a moderate or large tree and grows well in semi-dry lands. It helps to restore soil fertility, increase ground water table and provide good habitat for insect fauna. Other plant species must be also investigated for their viability for the production

of bio-diesel on cost-effective basis. As almost all plant species mentioned earlier do not require large amount of water and fertilizer, they are highly suitable in semi-dry lands. About 65 million hectare total wasteland is available including 14 million hectares of wasteland in forests under Joint Forest Management as per the Planning Commission Report. There is a potential to cover this wasteland with these bio-diesel plant species. Therefore, bio-sources are expected to be potential options for the production of fuel in order to ensure a continuity of fuel supply to our transportation and industrial sectors.

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