Executive Summary

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Biodiesel from Jatropha: are the high expectations justified?

IFEU publishes results of life cycle analysis for Jatropha biodiesel

For several years, Daimler AG has pursued a public-private partnership project on the production and utilisation of alternative transport fuels in India with the aim of promoting the cultivation of Jatropha for the production of biodiesel. Co-funded by Deutsche Investitions- und Entwicklungsgesellschaft, Cologne, Germany, this project was conducted in cooperation with and under the scientific support of project partners from the Central Salt & Marine Chemicals Research Institute, India, and the Institute of Animal Production in the Tropics and Subtropics at the University of Hohenheim, Stuttgart, Germany.

Jatropha, *Jatropha curcas* L., also called physic nut, is a shrub from the spurge family (Euphorbiaceae) found in subtropical and tropical habitats around the world. Growing even in dry climates on poor degraded soils where food production is not possible, Jatropha has the advantage of not competing against food or fodder production on this land. Jatropha produces oleiferous seeds. The oil from the Jatropha seed is very well suited for technical purposes and can be processed further, for example to Jatropha biodiesel.

Within this project, the IFEU-Institute for Energy and Environmental Research Heidelberg, Germany, was commissioned by Daimler AG to evaluate the environmental impacts of using this promising plant for biofuels. For this purpose, a so-called screening life cycle assessment (LCA) was conducted to compare the environmental impacts of Jatropha biodiesel to those of conventional diesel fuel along the entire life cycles. This screening LCA covers a number of environmental impact categories such as energy consumption, greenhouse effect, acidification, eutrophication, summer smog and ozone-depleting nitrous oxide emissions. IFEU's evaluation covers the existing pilot plant in India as well as decentralised and centralised options to process Jatropha oil, allowing for the deduction of general results that are valid in other parts of the world.

The major findings are as follows:

1. **Jatropha biodiesel in comparison to petroleum-based diesel fuel:** The substitution of Jatropha biodiesel for conventional diesel fuel can help save fossil resources and reduce the greenhouse gas emissions these fuels account for. These benefits, however, are associated with increased negative environmental impacts such as acidification, eutrophication and ozone depletion through nitrous oxide. Therefore, advantages and disadvantages have to be weighted against each other. If saving fossil resources and the reduction of greenhouse gas emissions are given the highest environmental priority, for example, then the production and utilisation of Jatropha biodiesel is desirable.
2. **Pilot plant in India:** The outcome reveals a considerable optimisation potential for the pilot plant that is currently being run in India. Due to the facility's high energy consumption, the Jatropha biodiesel from the pilot plant makes only a minor contribution of resource saving and greenhouse gas reduction. For a respective improvement, several measures should be considered such as increasing the operation efficiency and replacing coal or diesel fuel inputs into the process by combusting the shells of the Jatropha fruit which occur as a by-product from the Jatropha nut processing.
3. **Centralised or decentralised production?** Regarding the saving of greenhouse gas emissions and fossil resources, centralised Jatropha fruit processing facilities deliver better results than decentralised ones. The reason is that though the fruit must be transported over longer distances to

a centralised factory, the amount of extracted oil is greater and the specific energy consumption lower than in decentralised facilities.

4. **Utilisation of the by-products:** The uses of the by-products that are generated during the production of Jatropha biodiesel are crucial for the outcome of the life cycle balance. Using the by-products completely for energy generation allows for significantly higher greenhouse gas savings than their use as fodder or fertiliser. From an environmental perspective, it is therefore recommended to maximize the use of by-products for energy: the more environmental strain the electricity which is being replaced accounts for, the greater the greenhouse gas savings will be.
5. **Jatropha: in the tank or in a power plant?** The use of Jatropha biodiesel in a combined heat and power plant and the use in vehicles provide similar results regarding greenhouse effect. The amount of greenhouse gases saved depends primarily on the fossil energy carriers which are replaced by Jatropha biodiesel in the specific case. Jatropha biodiesel receives an especially good ranking when it replaces energy carriers that are particularly harmful to the environment such as coal in case of power plants or, in case of vehicles, diesel fuel with high sulphur levels which is still used today in many non-European countries.
6. **Cultivation on degraded soils:** The environmental advantages for Jatropha biofuels are great when the plant is cultivated on degraded, marginal and desert-like soils. If, however, the establishment of a Jatropha plantation leads to the reduction of the carbon stock of a certain area (as compared to the previous vegetation cover), the corresponding greenhouse gas balance can turn out to be unfavourable. It is therefore recommended to restrict the cultivation of Jatropha to sites where the removal of the existing vegetation does not lead to greenhouse gas emissions exceeding the amount which is sequestered by the future Jatropha plantation.
7. **Need for further research:** There is a lack of sound scientific data regarding the water consumption of Jatropha cultivation as well as its effect on biodiversity and soil fertility.

All in all, Jatropha has a considerable environmental potential, especially if the ecological and physiological advantages of the plant are made use of to the full extent. In order to achieve a sustainable use of Jatropha, however, economic and social aspects must be considered in addition to environmental issues. But with this, goal conflicts are very likely to turn up. For example, establishing highly efficient centralised processing facilities can interfere with the aim of developing decentralised areas and creating opportunities for rural populations. Therefore, the sustainable utilisation of Jatropha as a bioenergy carrier requires site-specific and comprehensive solutions.

Contact and downloads

IFEU Institute:

Dr. Guido Reinhardt
Dipl.-Geoökol. Nils Rettenmaier
IFEU Institute Heidelberg
Tel: +49-6221-4767-0
E-mail: nils.rettenmaier@ifeu.de
www.ifeu.de

Daimler AG:

Dr. Winfried Degen
Dr. Stefan Keppeler
Daimler AG, Stuttgart
Tel: +49-711-17-0
E-mail: winfried.degen@daimler.com
www.daimler.com