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WASTE OIL AS A RESOURCE FOR PRODUCTION OF BIODIESEL IN THE BANAT REGION

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Abstact: Increased use of renewable energy sources today is a relevant topic in transport sector, which is responsible for 84% of total CO_2 emission. Therefore, there is a tendency to use biodiesel as an alternative fuel, with its physicochemical properties similar to diesel fuel which during combustion in diesel engines emits much smaller amount of harmful gases into the environment. Advantages of using biodiesel are multiple, which is why countries of the European Union tend to use it more. To reduce the price of biodiesel, which would have a positive impact on increasing its use, this paper considered the possibility of using waste edible oil as raw material for biodiesel production in the Banat region. Highlighted are ecological, energy and economic benefits of using waste edible oil as a resource for production of biodiesel, as well as its disadvantages.
Keywords: biodiesel, waste oil

1. INTRODUCTION

Increased emission involved in creation of greenhouse effect (mainly due to increased demand and use of fossil fuels) and its impact on the global climate is the reason for actions that are trying to reduce emission of these gases, especially CO_2. As energy demands increase and fossil fuels are limited, research is directed towards alternative renewable fuels [1-2].The advantages of using this alternative fuel are its renewability, biodegrability and better quality exhaust gases [3]. In addition, burning of vegetable-oil based fuel does not contribute to net atmospheric CO_2 level because such fuel is made from agricultural materials which are produced via photosynthetic carbon fixation. The substitution of conventional diesel fuels with fatty acid methyl esters already comprises a commercial activity in many countries of the world [4-5]. However, the use of biodiesel has not expanded into developing countries, due to the higher prices than conventional diesel. The higher cost of biodiesel is due to its production mostly from expensive high-quality oil. Use of low-cost feedstock such as waste frying oils and non-edible oils should help to make biodiesel competitive in price with petroleum diesel [6-7].

2. MATERIAL AND METHODS

Biodiesel and its benefits

Within the sectors which use the final form of energy, transport sector is the most important, firstly because of its share in final consumption (over 30% of total energy consumption) and, secondly, because of its almost complete dependence on liquid fossil fuels. Transport policy is therefore a priority area in improving energy efficiency. Road traffic is of particular importance since it is responsible for 84% of total CO_2 emission from the transport sector.

Liquid biofuels are the only renewable energy source that can be used without changing the current technology of vehicles. Biodiesel (fatty acid methyl ester) is an alternative fuel similar in physical and chemical characteristics to diesel fuel [8]. Biodiesel has higher oxygen content than petroleum diesel and its use in diesel engines have shown great reduction in emission of particulate matter, carbon monoxide, sulfur, polyaromatics, hydrocarbons, smoke and noise [9-10]. It is suitable for

replacing fossil diesel in engines of agricultural machinery, trucks, buses and cars without (or with minimal) modifications to the engine and engine equipment. Biodiesel is non-toxic, biodegradable, and compared to conventional diesel fuel during combustion in engines, emission of harmful compounds is significantly lower [11]. It is most commonly obtained by transesterification of triglycerides of vegetable oils or animal fats with methanol in presence of an alkali or an acid catalyst [12]. In the market of liquid fuels in some countries it is sold in pure form or mixed with mineral diesel fuel in any proportion. Interest in biodiesel production has grown rapidly in the last 10 years. The first quantities of commercially made biodiesel emerged in the EU at the beginning of 90s, and the estimated rise in the EU in recent years has reached 35% per annum. Banat has an enormous potential to produce biodiesel. Moreover, it is very well geographically located and has a strong agricultural tradition.

Waste oil as a resource for production of biodiesel

The EU Thematic Strategy on prevention and recycling of waste, known as the EU Thematic Strategy on Waste aims to prevent waste generation, and to use waste as a resource, especially for raw material and energy. On the other hand, there is a warning that the internal market should facilitate recycling and reuse with setting high environmental standards.

One of the basic problems of both developed countries and societies in transition is the increased waste generation, especially waste vegetable oil. Waste edible oil is oil resulting from catering and tourist activities, in industry, health service, public administration and other similar activities. It is estimated that in developed countries about 10% of the used vegetable oil can be collected compared to consumption of edible vegetable oil. In less developed countries, this percentage is lower. According to the Mittelbach (2002) [13], it is realistic to collect about 3 liters of waste edible oil and fats per capita in Austria. Given that the consumption of edible oil in Austria is about 30 liters per capita and in Serbia about 16 liters, it is estimated that in Serbia it would be possible to collect about 1.5 liters of waste edible oils per capita. In Serbia there is no organized system for proper collection and treatment of waste oil and almost the entire amount is spilled, polluting water and land resources, it is improperly incinerated, emitting harmful compounds into the atmosphere, and mixed with animal feed.

Waste edible oil from households and restaurants that costs two to three times less than the price of fresh pressed oil, in addition to fresh vegetable oil and animal fats, provides raw material for biodiesel production. However, waste oil from food in the total production of biodiesel is poorly represented (about 1%), for which there are several reasons:

- significantly higher content of free fatty acids in comparison to fresh oil, which requires preparation of raw materials,
- insufficient information about potential quantities of waste oil,
- additional transport costs in collecting waste oil.

Generators of waste oil in the Banat region

Generators of waste edible oil are objects in catering and tourism, industry, health service, public administration and other similar activities in which more than 20 meals per day are prepared [14]. In the Banat region 225 buildings are identified which are used for food preparation. In these facilities in some periods (during the week) less than 20 meals a day are prepared, so that they do not directly fall under impact of the Law on Waste Management and regulations regarding management of waste oil. According to census of 2002, the Banat region has the population of about 680,000. Given that the consumption of edible oil in Banat is about 16 liters per capita, it is estimated that about 1.5 liters of waste edible oil per capita could be collected. This means that in Banat annually about 1,020 tons of waste edible oil could be collected. In addition to households, catering facilities and all other facilities in which food is prepared (canteens, hospitals, nursing homes, spas, fish shops, etc.) also represent a great potential, and they represent a real potential for collection of waste cooking oil. Figure 1 is a graph showing the dynamics of generating waste oil in the Banat region on a monthly basis. In addition to the values for generating waste oil the amount of consumed fresh oil in food preparation is also presented. Of the total oil used for cooking, 43% remains as waste.

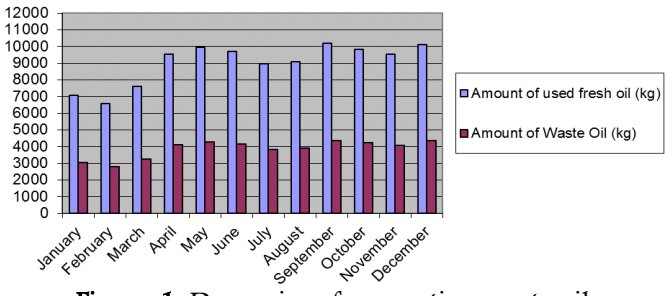

Figure 1. Dynamics of generating waste oil

3. RESULTS AND DISCUSSION

Ecological aspect of using waste oil for production of biodiesel

Due to lack of a system for management of waste edible oil which would include all aspects of this type of waste, more than 80% of this waste is improperly and uncontrolably spilled into waterways, discharged into sewers, mixed with communal waste and disposed of in landfills. Waste edible oil from restaurants is also used in livestock feed mixed with animal feed.

Inadequate waste disposal in unsanitary dumps leads to pollution of soil and groundwater. Rainfall filtered through the mass of deposited waste decomposes harmful substances, thereby contaminating the soil and groundwater. Additional problem is that pollution of the soil does not have only local character, but leads to pollution of soil and groundwater and surface water in the wider area and, indirectly, to the endangerment of flora and fauna on the surface.

Using waste oil as a resource for producing biodiesel has several positive effects in terms of environmental protection: to eliminate the problem of disposal of waste oil and increase the amount of biodiesel produced, the use of which globally affects the reduction in emission of greenhouse gases.

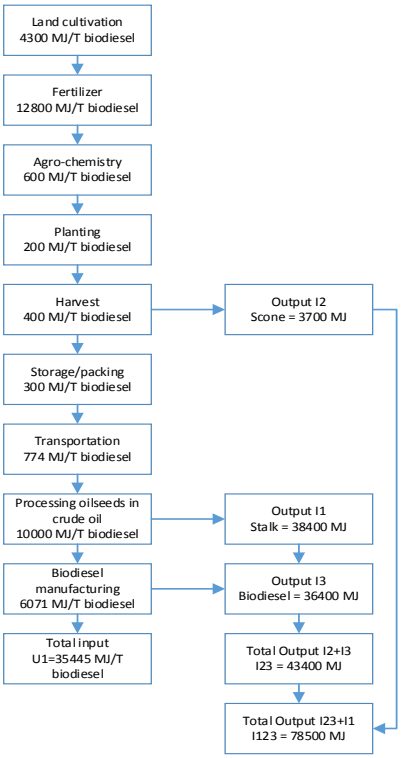

Figure 2. Energy balance in production of biodiesel from oil crops

Energy aspect of biodiesel production from waste edible oil

By analysis of energy consumption for production of one ton of biodiesel, if we take into account all the necessary stages shown in Figure 2, we can conclude that to produce 1 t of biodiesel from crude oil 35 445 MJ is required.

In analysis of energy consumption of biodiesel production from waste edible oil, the most important components are transport costs in collection of waste oil. Table 1 presents energy consumption in production of biodiesel from waste oil in the Banat region. Energy required to produce one ton of biodiesel from waste edible oil is 6618.21 MJ.

In order to collect 1200 kg of waste oil in the Banat region, which is necessary to produce 1 ton of biodiesel, 53 liters of fuel are required and 1659,11 MJ of energy. If this is compared with the data that for production of crude oil from oilseeds requires 29.374 MJ / t of biodiesel, the conclusion is that energy savings achieved by collecting waste oil is 27,714.89 MJ / t of biodiesel, or 81.33%. Table 1 shows two values: energy consumption with oil (U1) and energy consumption without oil (U2). This is done to demonstrate full benefit of using waste oil as raw material for biodiesel production. Data on energy consumption without oil, which was almost disposed of, shows direct energy consumption for production of biodiesel from waste oil collected at the waste generator. Of course, in energy analysis of the process of biodiesel production from waste and fresh oil there must be information on the process inputs and outputs, in order to obtain information on gains or losses.

Table 1. Energy balance of biodiesel production from waste oil

Description of activity	Unit	Relative density kg/litre	Quantity litre	Mass kg	Energy value, MJ/kg	Energy consumption MJ / ton biodiesel
Collecting waste oil (fuel)	litre	0,860	53	45,58	36,4	1659,11
Methanol + catalyst	litar	0,795	244	202	23,65	4777,3
Waste oil	litre	0,913	1100	1195,7	37,3	44599,61
Hot water (80°C)	kWh	-	30	-	-	108
Electric energy	kWh	-	20,5	-	-	73,8
Total energy consumption with oil (U_1)						51217,82
Total energy consumption without oil (U_2)						6618,21

Economic aspect of biodiesel production from waste edible oil

The main reactant in production of biodiesel is vegetable oil (rarely fat), so the basic price of biodiesel depends on the price of oil (i.e. technologies for oil production), i.e. the price of raw materials. In the early 90s of the last century, when the biodiesel industry faced great initial costs, contracted price for rapeseed used in production of biodiesel was significantly lower than the rapeseed grown for human consumption.

Market price of crude sunflower, rapeseed and palm oil ranges from 950 - 1300 € / t, depending on manufacturer, the amount and the supplier or importer, regarding palm oil. The price of waste vegetable oil on the market ranges from 200 - 300 € / t, depending on the amount available and suppliers, as well as whether waste oil is collected independently or bought directly from operators. In case when it is collected, direct costs include costs of transport, i.e. collecting and costs of labour. Analyzed data shows that the price of waste oil is 4 to 5 times lower than purchase of crude oil.
The biggest problem with this raw material is that waste oil has different characteristics and is usually mixed with animal fat, organic waste, and has a significant percentage of water. Different quality of oil complicates technological process of biodiesel production. Since the most usual is a batch process of alcoholysis, it is necessary to check the quality of each batch of oil in order to make technological process of alcoholysis optimal.
Another major problem is that the market does not have a constant inflow of this type of waste. The reason is that part of this waste is used as a feed additive due to low prices, despite the fact that it is harmful to animals, lack of information about options for disposal and recycling waste edible oil, insufficiently developed awareness about environmental protection and increasing energy efficiency, use of alternative fuels and underdeveloped system for collection and disposal of waste oil.

4. CONCLUSION

Use of waste edible oil for biodiesel production has several advantages:

- it eliminates the problem of disposal of waste oil in landfills, watercourses and sewage systems;
- it eliminates the problem of feeding livestock with toxic waste fats;
- it increases the production of biodiesel as alternative fuel, which influences the reduced emission of greenhouse gases.

Using waste edible oil for biodiesel production also affects decrease in prices of biodiesel due to:

- energy savings in production process of biodiesel from waste oil in relation to crude oil;
- lower prices of waste oil compared to crude oil as raw material.

In order to increase the percentage of use of waste oil for biodiesel production it is necessary to:

- perform better control of waste disposal;
- develop system for collection of waste oil;
- educate citizens about consequences of improper disposal of waste on environment and thus themselves;
- educate citizens on possibilities of increasing energy efficiency at local and global levels.

Disadvantages of using waste oil as raw material for biodiesel production in relation to crude oil are reflected in the following:

- Biodiesel produced from waste edible oil has more increased viscosity and poorer cold properties than biodiesel produced from pure vegetable oil, which is a result of changed structure of fatty acids in process of food preparation.
- Reaching better quality of biodiesel from waste edible oil is achieved by mixing it with fresh vegetable oil, because waste edible oil alone cannot meet quality requirements EN 14214th

Note: This paper is based on the paper presented at The Vth International Conference Industrial Engineering and Environmental Protection 2015 – IIZS 2015, University of Novi Sad, Technical Faculty „Mihajlo Pupin", Zrenjanin, SERBIA, October 15-16th, 2015, referred here as[16].

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