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Current state of the biodiesel production and the indigenous feedstock potential in Serbia

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ABSTRACT

This paper summarizes the biodiesel production capacities and the indigenous oil-based feedstock potential of Serbia for the first time. The current demands and future trends in diesel fuel consumption in Serbia are presented in order to estimate the biodiesel perspectives. The comprehensive review explores the potentials of the available conventional biodiesel sources (oilseed crops), as well as the next generation biodiesel sources, including waste cooking oil and oil from non-edible agro-food wastes that were previously reported as potential biodiesel feedstock in Europe. Results suggest that the Serbian agriculture can provide oilseed crops for the production of 128,000–266,000 t of biodiesel annually in addition to the quantities of oilseed crops required by the domestic food and fodder industries. Nevertheless, selecting edible vegetable oils as a potential feedstock for biodiesel cannot be considered as a long-term choice due to the associated "food versus fuel" debate. Thus, exploring the non-edible waste feedstock is important. Around 10,000 t of biodiesel could be produced from the collectable waste cooking oil. Other potential alternative oil resources indigenous for Serbia, such as tomato, grape and tobacco seeds, can provide raw material for the production of further ca. 8,000 t of biodiesel annually. Lack of governmental incentives and higher profitability of the edible oil sector have caused that the installed capacities for biodiesel production (ca. 126,000 t annually) are largely out of operation since 2008. Nevertheless, the results suggest that with the introduction of appropriate measures there is a realistic basis to fulfil the goals set by the National Renewable Energy Action Plan which requires that the annual biodiesel production from domestic sources should reach 98,000 t by 2020 in Serbia.

1. Introduction

Diesel fuel is the most consumed petroleum-derived engine fuel and its usage share is rising continuously [1]. The tax incentivized shift from gasoline to diesel began some 25 years ago and led to decline in gasoline consumption as well as a shortage of diesel production in the EU [2]. However, variable and hardly predictable petroleum prices, the finite nature of fossil fuels, their negative impacts on the environment, and health and safety considerations, emphasize the importance and necessity to develop domestically available, renewable and environmentally friendly alternatives to fossil diesel.

Biodiesel is a biomass-derived fuel that is considered to be one of the most promising petroleum diesel fuel substitutes. It is a biodegradable, non-toxic, almost sulphur-free and non-aromatic fuel derived from vegetable oils or animal fats. Chemically, biodiesel is a mixture of monoalkyl (usually methyl-) esters of long chain fatty acids (i.e. fatty acid methyl esters (FAME)) derived by alcoholysis of triacylglycerols (triglycerides) from a renewable lipid feedstock. Alcoholysis (transesterification) can be chemically or enzyme catalysed. Chemically catalysed (base or acid) alcoholysis can be homogeneous or heterogeneous, while the enzyme used as the catalyst are lipases. One of the alternatives to the catalysed processes is transesterification in supercritical methanol [3], which occurs at high temperatures and pressures and still do not have any practical (industrial-scale) application [4]. All of the approaches in the biodiesel production have their own advantages and disadvantages which are summarized in recent reviews [5–7]. Ester type biodiesel (i.e. FAME-based biodiesel) should not to be confused with other diesel substitute of renewable origin such as green or renewable diesel, which is produced via catalytic hydroprocessing of vegetable oils and fats, representing chemically quite different product that consists of a mixture of diesel boiling range hydrocarbons essentially free of aromatic compounds [8].

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Biodiesel has been attracting increasing attention worldwide as a blending component or a direct replacement for diesel fuel in vehicle engines [9]. Biodiesel blends with diesel are referred to as BXX, where XX indicates the amount of biodiesel in the blend; B100 denotes pure (100%) biodiesel. Mostly, 20% biodiesel share (B20) or lower in the blends with diesel has been utilized by biodiesel marketers and end users and they can be used in all diesel engines without modification [10]. The European standard EN 590:2009 (Automotive fuels-Diesel-Requirements and test methods) based on Directive 98/70/EC [11] recognizes the 7% (v/v) blend of biodiesel in diesel (i.e. B7) for now; biodiesel used for the blending has to comply with biodiesel standard EN 14214:2012 (Automotive fuels - Fatty acid methyl esters (FAME) for use in diesel engines - Requirements and test methods). Nevertheless, in order to facilitate the effective marketing of biofuels, European Committee for Standardisation just recently introduced the EN 16709:2015 standard specifying requirements for marketed and delivered high FAME-diesel blends (B20 and B30) for use in diesel engine vehicles (in captive fleets that are intended to have an appropriate fuel management). Moreover, the EN 16734:2016 standard on requirements and test methods for automotive B10 diesel fuel is expected to be published by the end of February 2017 at the latest [12]. In USA, American Society for Testing and Materials (ASTM) has approved a specification ASTM D7467-13 for diesel fuel blends containing 6–20% of biodiesel that has to fulfil requirements of ASTM D6751 [10]. Comparison of the selected specifications from the available EN and ASTM biodiesel standards is presented in Table 1.

Biodiesel production and the feedstock potential in Turkey [15], China [16], Bangladesh [17], Malaysia [18], Australia [19] and Africa [20] have been recently summarized and published. Generally, these regions cover a large surface area and they are endowed with natural resources, including plentiful oily feedstock for the biodiesel production. However, there is a lack of information about the biodiesel production potential in smaller, developing countries, which heavily relies on imports of the majority of the energy: what are their chances to follow the latest trend to introduce biodiesel among other biofuels based on domestic resources in order to mitigate the fossil fuel dependence and to decrease negative effects on the environment and climate.

Thus, this paper aims to investigate the current status and prospects of the biodiesel production and the potentials of indigenous feedstock materials as biodiesel sources in Serbia, a middle-income country between the Central and Southeast Europe, which is endowed with natural and mineral resources, but supplies the majority of its energy and oil needs by import. It is a first comprehensive review on the capabilities of Serbia to introduce biodiesel in the transport sector and/or to position itself as the biodiesel feedstock supplier, exploring the potentials of the various conventional and alternative sources, and, in this way, complementing previous studies on other Serbian renewable energy sources potentials (e.g [21–28]).

Firstly, feedstock materials for biodiesel production are shortly reviewed, including data on conventional (so-called 1st generation) and next generation (non-edible) biodiesel sources in Europe (Section 2). This is followed by a brief presentation of the main fossil energy resources structure and goals of the National Renewable Energy Action Plan of the Republic of Serbia (NREAP) regarding biofuels use in the sector of transport, development of the biodiesel production and the installed capacities, which are described and compared with the neighbouring countries (Section 3).

Particular attention is paid to the principal oilseed crops as biodiesel feedstock in Serbia. The total 1st generation biodiesel production potential is discussed by balancing between available areas for cultivation of oilseed crops, and domestic edible oil and fodder requirements. Main constrains and uncertainties associated with biodiesel production in Serbia are also discussed (Section 4).

Table 1
Selected property specifications (ranges, minimum (min) or maximum (max) values) for biodiesel and its blends with diesel according to different standards.

Fuel		B100	B100	B6–B20	B20	B30
Standard		ASTM D6751 [13,14]	EN 14214[a]	ASTM D7467 [14]	EN 16709[b]	
Property specifications	Unit					
FAME content	vol%		96.5	6–20	14.0–20.0	24.0–30.0
Flash point	°C	130 min	101 min	52 min	55 min	
Cloud point	°C	−3 to −12		NS[c]		
Pour point	°C	−15 to −16		NS[c]		
Cold filter plugging point	°C	Max +5	NS[c]	NS[c]	NS[c]	NS[c]
Cetane number		47 min	51 min	40 min	51 min	51 min
Density at 15 °C	kg m^{-3}	880	680–900	NS	820–860	825–865
Kinematic viscosity at 40 °C	$mm^2 s^{-1}$	1.9–6.0	3.5–5.0	1.9–4.1	2.000–4.620	2.000–4.650
Iodine number	g I_2 $(100 g)^{-1}$	–	120	–		
Acid number	mg KOH g^{-1}	0.5 max	0.5 max	0.30 max		
Oxidation stability	h	–	8 h min	6 h min	20 h min	20 h min
Carbon residue	mass%	0.05 max	0.3 max			
Copper corrosion		No. 3 max	Class 1			
Distillation temperature	°C	360				
Lubricity	µm	520 max				
Sulphated ash content		0.002 mass% max	0.02 mass% max	15 ppm max	10 ppm max	10 ppm max
Ash content	mass%	–			0.010	0.010
Water and sediment		0.005 vol%	500 mg kg^{-1} max			
Moisture			0.05 mass% max		260 ppm	290 ppm
Monoglycerides	mass%		0.7 max			
Diglycerides	mass%		0.2 max			
Triglycerides	mass%		0.2 max			
Free glycerine	mass%	0.02 max	0.02 max			
Total glycerine	mass%	0.24	0.25			
Phosphorus		0.001 mass% max	4.00 mg kg^{-1} max			
Calcium	mass%		–			
Magnesium	mg L^{-1}		–		2.0 max	2.0 max

[a] EN 14214:2012 – Automotive fuels – Fatty acid methyl esters (FAME) for use in diesel engines - Requirements and test methods.
[b] EN 16709:2015 – Automotive fuels – High FAME diesel fuel (B20 and B30) – Requirements and test methods.
[c] No specific limits are specified, but guidance is provided.