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The potential of bioash for utilization in road construction in eastern Croatia

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Abstract

In recent years usage of biomass as energy source has intensified in eastern Croatia. Newly built biomass power plants generate great amounts of bioash that is being disposed at landfills. Due to its favorable properties bioashes could be reused as alternative materials in road construction or road fundation. Therefore, research on application of bioashes in construction industry is being conducted at Faculty of Civil Engineering in Osijek. The main motivation behind this research, in a form of biomass and bioash production in eastern Croatia as well as international research on potential application of this types of bioashes, is show in this paper.

Key words: biomass, bioash, road construction, eastern Croatia, waste recycling

1 Introduction

Historically, usage of biomass as energy source has a long tradition in Croatia. Biomass was used on a small scale, for heating of houses and other objects and preparation of food. Today, prompted by ecological reasons and various European and state regulations, this renewable source is being used again for production of energy, but on a larger scale. Obligations prescribed by European Directive 2009/28/EC [1] to generate 20% of energy from renewable sources by 2020 has led to increased development of power plants that generate energy from biomass in recent years. From first such plant that was open in 2011, enticed by Strategy for energy development of Republic of Croatia [2], today there is 12 biomass fueled power plants with installed power of 25,955 MW and another 48 power plants (88,823 MW) waiting to start operating [3].

Production of energy from biomass in these newly developed plants is done through combustion with the by-product being biomass ash or bioash. Bioashes are inorganic materials that were either part of organic plant structure or mineral particles incorporated during harvesting, transportation and processing of biomass [4]. With the growing rate of biomass in overall energy production it is necessary to find the appropriate way of bioash reuse and recycling, with emphasis put on locally grown biomass sources, resulting bioashes and its properties. This is especially the case with eastern Croatia which is rich in biomass and where large number of Croatian biomass fueled power plants are situated. Considering good physical and chemical properties of bioash, reuse in construction industry could be beneficial economically and ecologically since it would limit the depletion of natural materials and reduce the load on landfills. Therefore, at Faculty of Civil Engineering research on possible applications of locally produced bioashes as a building material is currently being conducted. The research is driven by the various types of biomass cultivated and incinerated in nearby area and the potential it has to be used in road construction, a review of which is shown in this paper.

2 Bioash production and potential in eastern Croatia

Eastern Croatia is situated in lowland of Pannonian Basin and framed by three large rivers Sava, Drava, Danube and mountains surrounding Požega valley. It is comprised of 5 counties: Osijek-Baranja, Vukovar-Srijem, Brod-Posavina, Požega-Slavonia and Virovitica-Podravina. This mostly flat and fertile area has optimal conditions for agricultural production which is a significant component of its economy. Agricultural residues and waste from processing crops could be used as viable source of biomass for energy production. Eastern Croatia is also rich with forests that were historically used as a source of both energy and building materials.



Figure 1: Distribution of biomass power plants

This wealth of natural resources resulted in placement of almost half of Croatian biomass plants in eastern counties (figure 1.). Out of 12 currently operating plants 6 are in eastern Croatia with installed power of 19,155 MW and another 23 of them are planned to start operating [3]. Figure 2. shows their location by counties.



OPERATING BIOMASS POWER PLANTS

BIOMASS POWER PLANTS WAITING TO BE PUT INTO OPERATION OSIJEK-BARANJA COUNTY VUKOVAR – SRIJEM COUNTY BROD-POSAVINA COUNTY POŽEGA-SLAVONIA COUNTY VIROVITICA-PODRAVINA COUNTY

Figure 2: Location of biomass power plant in eastern Croatia

2.1 Wood biomass

Introduction of wood biomass power plants to these areas came from wood processing factories that have recognized the potential that biomass, as energy source, has on lowering the cost of production. Thus, they started installing cogeneration plants that use wood, bark and other residue for energy production.



Figure 3: Wood shredding (left); wood biomass combustion (right)

The first biomass cogeneration plant developed in Croatia is "Strizivojna Hrast" [5] situated near Đakovo city in Osijek-Baranja county. "Strizivojna Hrast" is a wood flooring factory that uses waste wood and bark as well as wood acquired from "Hrvatske Šume"^{*} for generation of energy (figure 3). The plant uses grate furnace for biomass combustion and develops 3,3 MW of electrical energy and around 6 MW of thermal energy. Daily, 110 t of wood biomass is burned or approximately 40 000t per year and three fractions of ashes are generated: bottom

^{*} "Hrvatske Šume" (eng. Croatian Forests) is a company that manages state-owned forests

ash, cyclon fly ash and electrofillter fly ash (figure 4.). Daily between 3 and 4 tons of all ashes combined are created and currently deposited at landfills.



Figure 4: Wood ash, left to right: bottom ash, cyclon fly ash, filtter fly ash

Along "Strizivojna Hrast" other notable biomass power plants that burn wood are: "Slavonia OIE" (4,66 MW), "Uni Viridas" (8,6 MW), "Spin Valis" (1,525 MW) [3]. The growing interest into wood biomass as energy source has also led to inclusion of two counties of eastern Croatia, Osijek-Baranja and Vukovar-Srijem, as partners in SRCplus program supported by European Commission. SRCplus project has a goal to support and speed-up development of local supply chains of short rotation woody crops that have growing period of 3 to 5 years on agricultural lands of lower quality [6].

To deal with resulting ash a review of international literature shows that it can be used in different layers of paved roads as well as for improvement of unpaved roads used in forestry and agriculture. Škels et al. [7] showed it can be used as binder for sand stabilization, while Vestin et al. [8] recorded improvement of bearing capacity of test section of forest road along with increase of mechanical properties measured in laboratories. Supancic and Obernberger [9] recorded stabilization effect of wooden bioash on coherent soils but the amount of bioash used needs to be greater than lime because of the lower content of CaO in bioash.

2.2 Sunflower hush

Sunflower is planted on about 24590 ha (2015) in eastern Croatia^{*} most of which is used for production of sunflower oil in "Tvornica ulja Čepin" near Osijek. During production of oil a byproduct in a form of sunflower husk is generated and used for production of thermal energy for technological steam. For combustion of sunflower husk, a grate furnace is used with the temperature of combustion between 750 and 800°C. Leftover, after the combustion, is 3% ash which amounts to 1,3 t of ash deposited every to 2 to 3 days.

^{*} Data for Požega-Slavonia county is not available



Figure 5: Sunflower husk

Sunflower ash is high in plant nutrients that are common in commercial fertilizers, so reuse in agriculture is one of the possibilities. But recent research has shown that this kind of ash might not be suitable as fertilizer according to Croatian regulations in agriculture due to high amounts of Zn and Cu [10]. An alternative to this could be application in different aspects of construction industry. It has been shown that sunflower husk ash reduces the plasticity of clay in ceramic industry [11] so a similar effect might be found for in situ modification of soil properties for road construction but further research is needed.



Figure 6: Sunflower husk ash

2.3 Other agricultural waste and residue

Cereals are the highest grown crops on agricultural lands in eastern Croatia (table 1.) with wheat, corn and barley accounting for significant amount. Residue resulting from harvesting and processing of this crops is used in agriculture by burning it or plowing it on the fields for plant nutrition, using it as straw or in other forms for animal farming. Currently, to the authors knowledge, there is no big power plant that incinerates solely one of these biomasses. A part of this residue is being incinerated locally as mixed source fuel for energy in various smaller power plants and a part is transported across the border to Hungary to be used for energy production in power plant in Pecs.

Table 1: Agricultural production in eastern Croatia						
county	Osijek-	Vukovar-	Brod-	Virovitica-	Požega-	
	Baranja [12]	Srijem [13]	Posavina	Podravina	Slavonia	
category			[14]	[15]		
Arable land	200 892 ha	149 703 ha	83 971 ha	99 062 ha	Not available	
Cereals in	63%	54%	55,63%	58,65%		
agricultural						
production						
Wheat	48 000ha	31 962 ha	10 870 ha	12 647 ha		
	288 000 t	188 576 t				
Barley	10 000ha	6 676 ha	4 929 ha	1 797 ha		
	50 000 t	32 712 t				
Corn	83 700 ha	28 129 ha	16 146 ha	21 761 ha		
	711 450 t	182 838 t				

Table 1: Agricultural	production in eastern Croatia

Literature review on application of wheat straw and corn cob ashes shows that within construction industry it is limited to research as partial cement replacement in concretes. This ashes due to SiO₂ content [16] show pozzolanic properties which is beneficial for long term strength development in concretes. Specific research on application of ashes from cereals in different pavement layers, apart from concrete, is not available. Considering favorable chemical composition of cereal ashes there is a need for research of potential of its application in soil stabilization and bound layers of pavement.

3 **Closing remarks**

Potential of biomass as renewable source of energy in eastern Croatia is very high and encompasses both woody and agricultural biomass. The growing number of biomass power plants and targeted cultivation of wood biomass for energy generation are causing the need for research and finding the best solution for disposal or reuse of increasing amounts of produced bioashes. International research has shown that bioashes have great potential as road building materials and should not be treated as waste, but rather as valuable byproduct. The positive international experiences should be used only as encouragement for further research on locally generated ashes and examples of possible application. For any wider application of bioash, due to the variability in location and condition of biomass cultivation and conditions of incineration, behavior of bioashes in a particular part of the road should be examined before any use. This should result in wider application of bioash, expand exisiting knowledge on bioash and help in optimizing bioash application.

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