

## INVESTIGATION OF THE AVAILABILITY OF BIOMASS ASHES IN AP VOJVODINA

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UDK: 662.613.11(497.113)

DOI: 10.14415/konferencijaGFS2018.026

**Summary:** *In Vojvodina, where crop husbandry is the most widespread agricultural production, straw/shells combustion represents a perspective way for renewable energy and there is a serious interest from farmers for biomass utilization for energy purposes. The average yearly biomass wastes in Vojvodina make 9 million tons only in the agriculture. The energetic use of the post-harvest residues is the technological combustion process by which large amount of ash is generated. These ashes are, in Serbia, either used as a fertilizer or disposed on the landfills, occupying valuable land and polluting the environment. This paper provides data on the availability of biomass ashes in Vojvodina and experimental analysis of their possible application as an mineral additive in cement-based composites. This research is supported by IPA Interreg project - Agricultural Waste – Challenges and Business Opportunities.*

**Key words:** *biomass, combustion, ash, waste, mineral additive*

### 1. INTRODUCTION

Biomass is one of the resources that could play a substantial role in a more diverse and sustainable energy mix. Energy obtained from biomass is a form of renewable energy and, in principle, utilization of this energy does not add “new” carbon dioxide to the atmosphere, in contrast to fossil fuels. Various biomass forms, suitable for thermochemical and bio-chemical conversion to other energy forms, are generated in the Province of Vojvodina. Waste biomass is generated in several production sectors: forestry, wood processing industry, crop husbandry, animal husbandry, fruit and vine growing etc. It was estimated that around 9 million tons of waste biomass per year is generated in the agricultural sector of AP Vojvodina. These amounts are more or less constant on a yearly basis [1]. The main processes by which energy can be obtained from biomass include direct combustion, pyrolysis, gasification, hydro gasification, liquefaction, alcoholic fermentation etc. As a waste product during these processes, large amount of biomass ash is generated. These ashes are, in Serbia, mainly disposed on the

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landfills, occupying valuable land and polluting the environment. The chemical characteristics of biomass ashes depend on the types and quality of the burned material and the operating conditions and technology of the biomass facility. Many kinds of biomass ash have similar pozzolanic properties as coal fly ash, such as those from rice husk, wood, wheat straw and sugar cane straw, some of which have been studied worldwide and used in concrete as mineral admixtures, improving the performance of concrete [2]. Based on this idea, Department for Materials and Structures from Osijek and Department of Civil Engineering and Geodesy from Novi Sad jointly work on IPA project Agricultural Waste – Challenges and Business Opportunities (Eco Build) in the period 2017-2020. Main idea of the project is to create a network for biomass/biomass ash users and providers, i.e. to agricultural subjects provide biomass to industry and solve problem of waste disposal. Networking of industry and construction companies will introduce a possibility of biomass ash use in civil engineering structures as an integral part of building. In the first period of the project implementation, team of experts from Department of Civil Engineering and Geodesy in Novi Sad investigated the availability of biomass ashes in AP Vojvodina, collected samples and tested pozzolanic properties of available biomass ashes. Results are briefly presented in this paper.

## 2. THE AVAILABILITY OF BIOMASS ASHES IN AP VOJVODINA

### 2.1. A visit to the producers of biomass ash - company Pro Mitrosrem

In the first period of the project realization, a study was conducted on the availability of biomass ashes in Vojvodina. A visit to the producers of biomass ash was done: company Pro Mitrosrem in Sremska Mitrovica. The FTN project team was introduced to the work of the company and their capacities, in terms of the produced quantities of biomass ash and the possibility of further use of the same for the needs of the project. Mitrosrem is an agricultural enterprise that owns 4,000 ha of land and uses additional 1,000 ha for crops (wheat, corn, soybean, sunflower, barley, rapeseed).



Figure 1 – Rolled biomass bales, ready for combustion



Figure 2 – Biomass ash, generated by combustion of biomass bales

In the boilers in the company wheat and soy straw are being combusted, in the form of biomass bales, for the production of heat energy (Figure 1). An average of 15 tonnes of biomass ash is generated per year, as a waste material of combustion of biomass (Figure 2).

## 2.2. A visit to the producers of biomass ash - company Soya Protein

Sojaprotein is the largest soybean processing factory in Serbia (in Bečej), and thanks to the diversity and quality of its products and a processing capacity of 250,000 tons per year, it also ranks among the most important soybean processors in Europe. In the boilers in the company two types of biomass: straw and shell are being combusted, for the production of heat energy (Figure 3). Reception of the material for combustion (silo waste) is mostly during the autumn (September/October). In winter, when there is no silo waste, the shell is burnt (sunflowers, soy and the like). An average of 3 tonnes of biomass ash is generated per day (Figure 4).



Figure 3 – Biomass straw for combustion



Figure 4 – Biomass ash, generated by combustion of biomass shells

## 2.3. A visit to the producers of biomass ash - company The Veterinary Institute

The Veterinary Institute in Subotica is the most comprehensive veterinary system in Serbia, and the only company that provides complete solution in the field of livestock farming – from the prevention of animal diseases, through animal nutrition, to animal treatment. Since 2014, there are 2 boiler rooms in operation. In addition to the boiler on the gas, the Institute uses the boiler on biomass, where straw pellet, instead of brown coal, is burnt: wheat, corn, barley, soya, etc (Figure 5). Approximately 200 tonnes of straw pellets are burnt per month, of which 10% of ash is generated, i.e.  $\approx 20$  tonnes of biomass ash per month (Figure 6).



Figure 5 – Straw pellets for combustion



Figure 6 – Biomass ash, generated by combustion of biomass pellets

#### 2.4. A visit to the producers of biomass ash - company Hipol a.d.

Hipol a.d. is a petrochemical industry company, located in Odžaci, whose main activity is the production of polypropylene, homopolymer, for most types of processing: extrusion, blow molding, injection molding, textile fibers and others. The company's capacity is 100 tons of propylene per day, or 30,000 tons annually. Since 2014, there is an additional boiler room in operation, where straw pellet, instead of oil fuel, is burnt: dominantly soya (Figure 7). Approximately 10.000 tonnes of straw pellets are burnt annually, of which approximately 10% of ash is generated, i.e. 700 tons of biomass ash (Figure 8).



Figure 7 – Straw pellets for combustion



Figure 8 – Biomass ash, deposited in ash dump room



### 2.5. A visit to the producers of biomass ash - company Victoria Starch

Victoria Starch, the youngest member company from the Victoria Group business system, began continuous production of agro-pellets, i.e. pellets from agricultural biomass, in mid-2013 in Zrenjanin. Agro-pellets are a cylindrical, smooth and odorless products obtained by pressing biomass – crop residue (soybean, wheat and rapeseed straw) under high pressure, without adding any binding agents (Figure 9). Agro-pellets have two main uses: for burning in boilers and as litter for breeding animals.

Energy pellets are agro-pellets from crop residue with a minimum soybean straw content of 50%. They can be used in all agro-pellet-fueled furnaces in households and public institutions, as well as pellet-fueled furnaces with mechanical grille cleaning. Pellets for animal litter are made of wheat straw. The company's capacity is over 1200 tons of pellets per month. Over 50% of pellets are distributed to company "ALMEX DOO" - "IPOK" Zrenjanin (about 1000 tons of pellets per month). As a waste product of biomass combustion, cca 700 kg of biomass ash is generated per month. Biomass ash is deposited on the landfill nearby company (Figure 10).



Figure 9 – Straw pellets in Victoria Starch



Figure 10 – Landfill – deposited ash

### 2.6. A visit to the producers of biomass ash - company ALMEX-IPOK

ALMEX-IPOK is a chemical company in Zrenjanin whose main activity is corn processing and starch production, with a capacity of 280 tons of maize daily processing. Within the company's work system, straw bales are collected, prepared by chipping in a chopper (Figure 11) and burned in a boiler room. Due to the discontinuity in the operation of straw bale chips in relation to the quantities that are being delivered, the company is using the agro-pellet from Victoria Starch in Zrenjanin. For preparation of pellets, wheat straw, soya straw and rapeseed are dominantly used as energy sources. Combustion of biomass (pellets, straw ...) generates biomass ash which is disposed in containers, and from there further transported to the city landfill as a waste. At the daily level, 40 tons of pellets are burnt, generating 2.5÷3 tons of biomass ash (Figure 12).



Figure 11 – Straw bales chopper



Figure 12 – Generated biomass ash

### 3. TESTING OF POZZOLANIC PROPERTIES OF COLLECTED SAMPLES OF BIOMASS ASHES

In order to determine the possibility of application of biomass ashes as a binder in cement based composites, their pozzolanic activity was tested. The pozzolanic activity was studied on specimens prepared according to the procedure given in SRPS B.C1.017-2001. Standard mortar prisms were prepared with biomass ash, slaked lime and quartz sand (Figures 9 and 10). The pozzolanic activity was determined based on 7 day compressive strength.



Figure 9 - Component materials for testing of the pozzolanic activity



Figure 10 - Standard mortar prisms for testing of the pozzolanic activity

Testing of pozzolanic properties showed that biomass ashes collected in Mitrosrem and ALMEX-IPOK have pozzolanic activity of Class 10, while ashes from Soya Protein and The Veterinary Institute have pozzolanic activity of Class 5. Biomass ashes, collected in Hipol and Victoria Starch have low pozzolanic activity that is not sufficient to express through Class. Results are given in Table 1. This is due to the poor cementitious properties of soya ash, as biomass combusted in Hipol are dominantly soya-based

pellets. Biomass ash, originating from Mitrosrem has the highest activity Class, as the company uses pure wheat straw as an energy source for combustion.

*Table 1: Pozzolanic activity of tested biomass ashes*

Ashes origin and type of biomass energent	$f_{zs,sr}$ [MPa]	$f_{zs,min}$ [MPa]	CLASS	$f_{p,sr}$ [MPa]	$f_{p,min}$ [MPa]	CLASS
Soya Protein (mixed wheat straw, soya husk and sunflower husk)	3,6	3,3	<b>10</b>	9,3	8,75	<b>5</b>
Mitrosrem (100% wheat straw)	3,4	3,3	<b>10</b>	11,0	10,3	<b>10</b>
The Veterinary Institute (straw pellet: 50% wheat and 50% soya)	3,1	3,05	<b>10</b>	9,63	8,75	<b>5</b>
Hipol a.d. (straw pellet: 100% soya)	1,6	1,45	/	4,06	3,84	/
Victoria Starch (straw pellet: 30% wheat and 70% soya)	/	/	/	1,40	1,25	/
ALMEX-IPOK (straw pellet: 50% wheat and 50% soya)	3,48	3,36	<b>10</b>	10,60	10,0	<b>10</b>

#### 4. CONCLUSION

The aim of this paper was to analyse the availability of biomass ashes in AP Vojvodina and determine the feasibility of their utilization in cement manufacturing, as pozzolanic materials. The investigation is supported by the IPA Interreg project – Eco build: Agricultural Waste – Challenges and Business Opportunities. Within the project, a group of researchers carried out several visits to the users of biomass (as an energy source) and, at the same time, producers of biomass ash (as a waste material) and got information of available quantities of biomass ashes at different companies. Samples of biomass ashes were collected and their pozzolanic (cementitious) properties were tested in the laboratory. Results are promising, as the ash collected in Mitrosrem (Sremska Mitrovica) and ALMEX IPOK (Zrenjanin) have the pozzolanic activity of Class 10, whereas ashes from Soya Protein (Bečej) and The Veterinary Institute (Subotica) have the pozzolanic activity of Class 5, hence they can be used as a mineral binder (replacement of cement) in concrete industry. Waste materials including coal fly ash, blast furnace slag, metakaolin and silica fume have been historically proven to provide benefit as supplementary cementitious materials. It is becoming increasingly evident that there is a growing need for additional materials that can be used in conjunction with or to replace ordinary portland cement. As the movement towards more environmentally

conscientious building materials endures, it is in the best interest of the construction industry to consider alternative materials that previously would have not been candidates for reuse. Limited research work has been reported on utilization of agro-waste (renewable sources) as a binder in concrete/mortar production. Thus, a complete study of engineering properties on every available agro-waste based cement composite could be conducted and compared with the conventional concrete.

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### Acknowledgements

The paper presents the part of research realized within the project “Application of new technologies for design and construction and improvement of educational process in civil engineering” conducted by the Department of Civil Engineering and Geodesy, Faculty of Technical Sciences, University of Novi Sad.

## ИСТРАЖИВАЊЕ ДОСТУПНОСТИ БИОПЕПЕЛА У ВОЈВОДИНИ

*Резиме:* У Војводини, где је ратарство највише распрострањена пољопривредна делатност, сагоревање сламе/љуски представља перспективан начин за производњу обновљиве енергије, а постоји и озбиљно интересовање пољопривредника за кориштење биомасе у енергетске сврхе. Просечни годишњи отпад биомасе у Војводини износи око 9 милиона тона у пољопривреди. Енергетска употреба остатака после жетве обухвата технолошки процес сагоревања којим се генерише велика количина пепела. Овај пепео се у Србији или користи као ђубриво или се депонује на депонијама, где заузима вредно земљиште и загађује животну средину. У раду су прикупљени подаци о расположивости биопепела у Војводини и дати су резултати експерименталног истраживања њихове могуће примене као минералног адитива у композитима на бази цемента. Ово истраживање је подржано пројектом IPA Interreg - Пољопривредни отпад - изазови и пословне могућности.

*Кључне речи:* Биомаса, сагоревање, пепео, отпад, минерални додатак