ANALYSIS OF THE AMOUNT OF ASH DURING SESSILE OAK (QUERCUS PETRAEA, MATTUSCHKA) WOOD COMBUSTION

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Abstract: The subject of investigation in this paper is the amount of ash residue during combustion of Sessile oak (Quercus petraea, Mattuschka) wood that is one of the most usable ones as fire wood in households in the Republic of Macedonia. The purpose of this investigation was to establish the amount of ash, as one of the biggest problems during energy production with forest biomass. The material for this investigation is collected from two different regions of the State, in order to eliminate or to emphasise the influence of different stand conditions. The results from the investigation show that during the sessile oak wood combustion the wood produces less ash than wood with bark, and bark produces the highest amounts of ash.

Key words: biomass, ash, residue, alternative energy

INTRODUCTION

The availability of energy is becoming a major issue, and the demand for energy is growing every day. Concerning that fact, as well as the fact that the reserves of fossil fuels, such as oil coal and natural gas are limited, the world is turning towards discovering and using alternative, environmentally friendly, and renewable energy resources. One of these resources is biomass from forests[1]. Wood has been used as an energy source since the early days. While in Western Europe the use of firewood decreased in favour of fossil fuels, large parts of human population in South-Eastern Europe (SEE) still depend on wood as energy source. In the wake of Kyotop Protocol the use of renewable resources for energy production has become a major issue in climate change mitigation [2]. Forest biomass plays a major role in the EU energy action plan (2020), as well as in most national policies in Europe. This interest in increased utilization of forest biomass resources raised questions on the potentials and limitations of forest ecosystems to produce biomass in a sustainable way. The importance of forests as a major source of global biodiversity has become well known during the recent decade. Not only as a source for the utilization of wood and other non-wood products, but also for providing a multitude of other ecosystem services and functions [3]. Biomass combustion is one of the most rapidly developed methods for green energy production, and the increased production of biomass ash needs further technical management. This management is divided into two parts – the first one dealing with the damages and corrosion of boilers, and the second one dealing with the large amount of residue that should be deposited somewhere. Wood ash is defined as the solid residue from biomass combustion that contains macro and micronutrients resistant to
high temperatures [4]. During wood combustion, its content is mostly oxidized except for nitrogen which is emitted through exhaust gases in the form of gaseous compounds (NOx). This means that almost all other biomass components are not incinerated and remain as a solid residue. Ash from wood combustion is mainly composed of calcium, potassium, magnesium, silica, aluminum, phosphorus, sodium, sulfur and manganese. In very small quantities (micronutrients) could be found: iron, zinc, arsenic, nickel, chromium, lead, mercury, copper, boron, molybdenum, vanadium, barium, cadmium and copper. In the case of incomplete biomass combustion, the amount of unburned carbon (C) might also be present inside the ash. It is considered that the amount of K, S, B, Cu and Na decreases with an increasing furnace temperature, while the quantity of Mg, P, Mn, Al, Fe, Si and Ca are not strongly influenced by temperature. Nevertheless, these assumptions cannot be generally applied since they depend also on the type of tree. Moreover, the lack of standardization of the methods used to evaluate the content of ash leads to further possible deviations[5].

MATERIALS AND METHODS

Forests in the Republic of Macedonia are mostly coppice, with low quality and very diverse in species. There are very little data on this topic available in the country [6, 7]. The first task was to establish two different stands of Sessile oak (Quercus petraea) in the country, one from Ohrid, and one from Valandovo area, in order to eliminate eventual impact of stand and ecological conditions on the results. Samples were collected from different parts of trees (1.3m, 5.3m, branches, bark and small branches) in order to eliminate eventual differences in the ash production from different parts of the tree. Brest high diameter of the examined trees was between 15 and 30 cm, in trees of coppice origin. The collected samples were then brought to the laboratory, where ash content was determined in accordance with the European Standard EN 14775:2009, Solid Biofuels –Method for the determination of ash content [10], and [12]. The percentage of ash is determined from the mass of residue remaining after the sample is burned. Ash content is expressed as the weight of ash as a percentage of the moisture-free dry weight (w/w) of the sample. The ash deposit was established for pure wood, mixed wood and bark and pure bark. The results were statistically processed.

RESULTS AND DISCUSSION

Ash residue from the Valandovo stand

There were 30 samples taken from the sessile oak from Valandovo stand. In 10 of them, ash residue was analyzed in pure wood (wood without bark), in 10 of them ash deposit was analyzed in wood with bark (approximately as their percentile share in the wood volume), and in 10 of them the residue was analyzed on pure bark. The results of the analysis show that most ash residue is produced during the combustion of bark, and less ash residue is produced during pure wood combustion (Figure 1).

![Figure 1. Ash residue from the Valandovo stand](image-url)
6.1% and 7.6%, averaging 6.86±0.1641, with standard deviation of 0.519±0.116 and a variation of 0.2693±0.0602.

### Ash residue from the Ohrid stand

There were 30 Sessile oak samples taken from the Ohrid stand. In 12 of them, ash residue was analyzed in pure wood (wood without bark), in 12 of them ash deposit was analyzed in wood with bark (approximately as their percentile share in the wood volume), and in 6 of them ash residue was analyzed in pure bark. The results of the analysis show that the most ash residue is produced during the combustion of bark, and less ash residue is produced during pure wood combustion (Figure 2).

The ash residue from pure wood from the Ohrid stand was in the outskirts between 0.08% and 0.25% of the burned volume, averaging 0.1367±0.0139, with a standard deviation of 0.0481±0.0098 and a variation of 0.0023±0.0005. The ash residue from wood and bark from the Ohrid stand was in the outskirts between 0.48% and 0.83%, averaging 0.6142±0.031, with a standard deviation of 0.1073±0.0219, and a variation of 0.0115±0.0024. The ash residue from bark from Ohrid stand was in the outskirts between 0.48% and 0.83%, averaging 0.6142±0.031, with a standard deviation of 0.1073±0.0219, and a variation of 0.0115±0.0024. The ash residue from bark from Ohrid stand was in the outskirts between 4.05% and 5.13%, averaging 4.5483±0.1678, with a standard deviation of 0.411±0.1187 and a variation of 0.1689±0.0488.

The results also show that there is no significant statistical difference in ash deposition during combustion of pure wood and wood with bark in both stands and between the stands, but that there is statistically significant difference during bark combustion.

### Ash residue for oak as species

Since there were no statistically significant differences in ash deposition during combustion of sessile oak wood between the two stands, we will present the average ash deposition for sessile oak as species (Figure 3).

The average ash residue of pure wood from both stands was in the outskirts between 0.03% and 0.25% of the burned volume, averaging 0.0893±0.0142, with a standard deviation of 0.0636±0.0101 and a variation of 0.0041±0.0006. The ash residue from wood and bark from both stands was in the outskirts between 0.48% and 1.21%, averaging 0.7955±0.0516, with a standard deviation of 0.2307±0.0355, and a variation of 0.0532±0.0084. The ash residue from bark from both stands was in the outskirts between 4.05% and 7.6%, averaging 5.9931±0.3116, with a standard deviation of 1.2465±0.2204 and a variation of 1.5539±0.2747.

As it is presented in Figure 3, there is no significant statistical difference while burning wood or wood with bark (T=0.0592), but there is statistically significant difference while burning only bark (T=3.3334).
CONCLUSIONS AND RECOMMENDATIONS

According to the results from this investigation the following conclusions can be drawn:

- There are no statistically significant differences in ash deposition during combustion of sessile oak wood from different stands, so we can conclude that the stand conditions do not influence the amount of ash deposition;
- There are no statistically significant differences in ash deposition while burning wood with or without bark in the normal natural ratio.
- There is statistically significant difference while burning only bark, and this condition gave more ash than burning wood.
- The results from this investigations are higher than typical values for broadleaved species according to EN 14961-1:2010 [11], for wood -0.3%, and for bark 1.5%, due to the small diameter of the material (copice oak) and slightly due to the ground contamination of the samples.

The fields of biomass ash use can be:

- Application in forest ecosystems
  Biomass ash might be used to restore those forest ecosystems which have suffered from deforestation and acidification of their land.
- Apply as fertilizer (fertilizer or supplement) in agricultural ecosystems
  Biomass ash residue, rich in nutrients, while also presenting a low concentration of heavy metals and organic contaminants, can be used as fertilizer for agricultural and horticultural activities [13].
- Implementation in geotechnical construction and industrial processes
  Typical applications in this area are the construction of roads (especially forest roads)[8] and parking areas, the use as a surface layer in landfills and use as an additive in the production of building materials (e.g. concrete, bricks or cement).

REFERENCES

NestorovskiLj.: Comparative Analysis of the energetic potential of forests as an renewable resources and the possibilities for its utilization in Republic of Macedonia, Skopje 2004.


Chiani F., Corradi C., Perugini L., Rappuoli V., Valentini E., Angelova E., NestorovskiLj.: Biomass Availability in the Territory of Republic of Macedonia, MOEPP, Skopje 2010;

seeger-greenenergy.com,

Biedermann F., Obernberge I.: Ash-related problems during biomass combustion and possibilities for sustainable ash utilization,

Nacevski M., Vasilevski K.: Influence of the age of annual tree ring on the amount of ash from the Black pine (P.nigra) wood from artificial stands, Skopje 1993;


EN 14775:2009, Solid Biofuels –Method for the determination of ash content

EN 14961-1:2010


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