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CHARACTERIZATION OF WOOD COMBUSTION FLY ASH IN A CONTEXT OF APPLICABILITY IN AGRICULTURE

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INTRODUCTION

One of the types of renewable energy production is cogeneration of heat and power from biomass. Cogeneration becomes more and more topical worldwide and in the Baltic States due to the possibility to utilize various kinds of rather easy obtainable biomass, e.g., forestry and agriculture residues or plants cultivated for biomass. For example, in 2015, in Lithuania more than a half (56%) of energy (power and heat) was produced at cogeneration plants.

The problem of cogeneration is production of ash in large amounts. The amount of produced ashes is impressive, e.g., 600,000 tons of peat-wood ashes is generated just in Finland every year. Thus, environmentally friendly and cost-effective solutions for ash utilization are required, avoiding ash landfilling.

The aim of the study was to characterize wood fly ash generated from wood biomass combustion in cogeneration power plants in a context of applicability in agriculture, particularly in respect to element content.

MATERIALS & METHODS

Samples of wood fly ash were obtained in September, 2016, from two cogeneration plants located in Latvia and Lithuania. Seven samples (each 500 g) of wood fly ash were collected during one week. Technical specification of the cogeneration power plants involved generation of power/heat (23.8 MW) with a technology of combustion as a moving grate, using fire-tube boiler and applying combustion temperature 950°C with capacity of the equipment 8,000 h per year. The main wood species used were conifers (95%) with a negligible addition of deciduous (5%), namely, birch 3% and alder 2%.

- Measurements of pH and electrical conductivity
- Measurements of total element content in *Aqua regia*
- **Characterization of wood fly ash**
- Loss-on-ignition (LOI) analysis
- Speciation analysis for assessment of element bioavailability

RESULTS

Results indicated high pH value as it is consistent with the occurrence of basic metal salts, oxides, hydroxides and carbonates (Fig.1). Other parameters are indicative.

Nutrient and element composition in ash is highly dependent on the source, quality and purity of wood and type of combustion equipment. Results revealed high average total amount of Ca, K, Mg, Mn, P, Al, Fe and Na in ashes (Fig.2). Content of P (6 g/kg) in tested ashes cannot be assessed as high, nor low, if compared to other studies where P ranged up to 14 g/kg. With high pH values also high content of alkali and alkaline metals was detected.

The greatest part of elements (Al, Ba, Cd, Cu, Co, Mg, Mn, P, Pb, Se, Ti, Tl) more than 90% and Zn, Sr, V more than 80% from the total amount were bound in residual fraction indicating their low bioavailability from fly ash (Fig.3). Only Cr, K, Mo and Ni were found in water soluble and acid soluble fractions (which are fractions of bioavailable compounds) in considerable amount (>60%).

In comparison with limits of elements set for ash applicable for utilization in forestry and agriculture in some European countries (Fig.4), obtained results indicated that only Cd might exceed permitted limit values, while concentration of all other elements was significantly below the proposed limits.

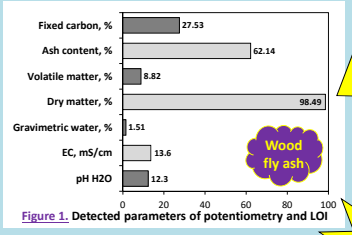


Figure 1. Detected parameters of potentiometry and LOI

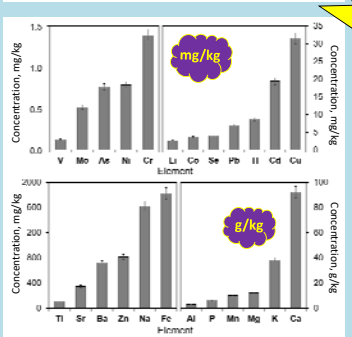


Figure 2. Total concentration of elements in analyzed wood fly ash

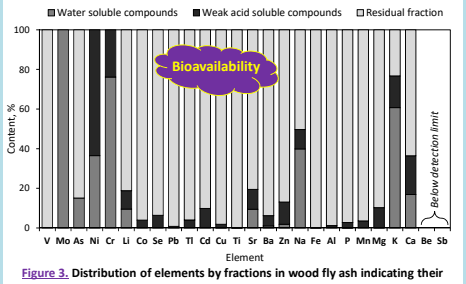
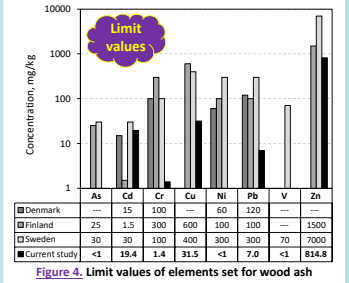


Figure 3. Distribution of elements by fractions in wood fly ash indicating their potential bioavailability *(water & weak acid soluble compounds – estimated high or medium potential bioavailability; residual fraction – low bioavailability)*



	As	Cd	Cr	Cu	Ni	Pb	V	Zn
Denmark	---	15	100	---	60	120	---	---
Finland	25	1.5	300	600	100	100	---	1500
Sweden	30	30	100	400	300	300	70	7000
Current study	<1	19.4	1.4	31.5	<1	7.0	<1	814.8

Figure 4. Limit values of elements set for wood ash utilization in forestry and agriculture in Europe in comparison to detected values *(--- not specified)*

CONCLUSIONS

- General properties of fly ash – alkaline pH (>12), high concentration of Ca, K and Mg and also considerable presence of P, Mn and Zn – suggest that wood fly ash could be used both, as a liming agent and a fertilizer. However, significant increase in soil pH and salinity (as indicated by EC) in soil is undesirable and may adversely affect plants. Wood ash can effectively be used for agricultural purposes of amelioration of acidic soils instead of liming if the calcium carbonate amount in ash is known. Wood ash could be used to improve nutrient availability and balance nutrient exported by tree harvesting in acidic forest soils. Due to the certain nutrient deficiency (like N), use of pure fly ash for soil enrichment is not the most effective. In N-limited soils, wood ash should be applied together with N fertilisers to counteract the nitrogen immobilization.
- Toxic heavy metal content of wood ash did not exceed the average values compared to the literature data. The greatest part of the elements was bound in residual fraction indicating their low bioavailability and only Cr, K, Mo and Ni were found in water soluble or bioavailable fractions in considerable amount. It indicates possible more or less non-toxic behaviour of these elements and, therefore, this fact is potentially usable for development of fertilizing agents using fly ash.
- Agricultural application of wood ash in overall has significant economic importance. Application of ash on agricultural and forest lands may lower the expenses of landfilling ash as a waste and can promote development of 'zero waste' concept.

ACKNOWLEDGEMENTS

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