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BIOMASS ASH UTILIZATION OPPORTUNITIES IN AGRICULTURE

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In Latvia and in the world there are problems with utilization of wood ash from large fireboxes because it is a technologically complicated, time consuming and costly process. The methods used to dispose of the ash when it is deposited in waste landfills are unsustainable. Pollution-increasing solution is needed since pure wood ash is a valuable source of plant nutrients. Ash contains the macro and microelements needed for plants and can replace some of the precious mineral fertilizers in agriculture, especially in organic. Ash use in agriculture is little explored and implemented, the use of the technology is not resolved (ash collection and screening, fractionation, drilling, evaluation, etc.). The LUA studies of ash and slurry mixing problem to prepare ash with mechanized spreaders. Cattle slurry is used as a binder that helps create solid ash fractions that are subject to dispersion with centrifugal fertilizer dispersers with a sufficiently good spreading quality. The research examines the conditions for the creation of different size fractions and their dissolution. The experimental results showed that the best used ratio of the mixtures was 1000 ml of ash and 200 ml of liquid manure or 1000 ml of ash and 300 ml of liquid manure. In this ratio, the produced granule size was very close to the size of mineral fertilizers.

Keywords: mixing,, slurry, wood ash, granulation

INTRODUCTION

Biomasses are organic materials that are derived from any living or recently-living structure. Plenty of biomasses are produced in the world. Biomasses are mostly combusted for heat and electricity produsing. Use of wood-based biomass for energy has been a major socio-economic function of forests all over the world. The potential negative impact on the forest ecosystem and surrounding environment due to an increased utilization of wood-based biomass for energy needs to be mitigated. Possibilities of using ashes in various branches of economy have been widely studied worldwide in recent years.

Wood ash is a residue powder that is left after combustion of wood in home or in industries. Typically 6-10% of the mass of burnt wood result in ash (Siddique, 2012). The type of wood, combustion temperature and combustion time play a vital role in the quantity of ash produced and its chemical composition. Renewable energy sources accounted for a 36.8% (approx. 69 PJ) share of the gross inland energy consumption in Latvia, 2014 (Central Statistical Bureau,2015). 82.1% of renewable energy was produced by different kinds of wood fuel, but 24.3% of it was produced in cogeneration plants (Central Statistical Bureau,2015). Energy wood is gradually becoming more and more important in the energy supply of Latvia. This is due to the European Union's decisions to increase the share of renewable energy in order to reach 20% of the share of renewable energy in total energy consumption in 2020.

Biomass heating systems are becoming increasingly popular because of the use of cheap local fuels, and thus promoting national energy independence. However, the use of such equipment results in the production of ash, which in Latvia, like many other parts of the world, is treated as industrial waste. As such, it is mostly deposited at landfills. For example, in 2012, more than 33 thousand tons of wood ash was produced in Latvia (Bekeris, 2015). Much of this ash is today considered as waste and is deposited on landfills at a considerable cost. Wood ash contains all the major mineral plant nutriens except nitrogen and has a liming effect when returned to the soil.

Environmental policies of the European Union aim to increase the amount of renewable energy and to improve the use of waste streams. This will increase the amount of ash from biomass combustion, thereby increasing the need for its utilization. Dumping high quality wood ash in landfill conflicts with public efforts to reduce the flow of waste to landfill. In recent years, attention has been focused on the use of ashes. As one of the options is wood ash recycling that returns the nutrients in the trees to their place of origin, i.e. forest soil. The ecological effects of ash recycling on flora, fauna and tree growth and on water and soil chemistry have been thoroughly studied in recent decades. These studies show that pure, non-contaminated and stabilised wood ash can be used as a compensatory fertiliser on forest soils without any significant negative impact on the environment, provided that the ash is applied with consideration to site specific conditions. The influence of wood ash on the soil chemical composition and biochemical parameters of young Scots pine was studied (Mandre, 2006).

The effect of fertilization with ashes on the above-and belowground biomass formation of Silver birch and Scots pine stands on peatland was investigated (Ots, 2017). Other wood ash mode of application is its use in forest road construction and maintenance. Ash from woody biomass contains a significant amount of CaO. Therefore, the substitution of burnt lime as a binder for silt and clay soil stabilisation by wood ash seems to be a reasonable way of ash utilization (Thurdin and etc. 2006, Oburger and etc, 2016).

With the advancement of the technology and increased field of applications of concrete and mortars it is possible to make it more suitable for by situations. The percentage of CaO, which is one of the important compounds in wood ash, varies from 4% to 70% in wood ash that makes it a potential substitute in cement industry either in the production or in the application stage. An investigation was performed with a view to establish various physical properties of wood ashes and to determine potential uses of wood ashes in cement-based construction materials (Siddique, 2012, Garsia and Sausa-Coutinho, 2013, Carrasco and etc 2014, Kizinievic 2016, Fernández-Pereira 2011).

Biomass ash adopted as the additive to increase freeammonia concentration in biogas slurry was investigated (Shuiping Y and etc. 2017), the effects of biomass ash on the composting process of separated organic fraction of municipal waste and the final product quality were studied (Asquer and etc.2017).

Wood Ash contains significant amounts of magnesium, potassium and many other micronutrients important to healthy crop growth. Wood ash has been chosen by farmers to increase the soil pH, improve the soil fertility and increase the crop yield. Wood ash has a liming effect of between 8 to 90 percent of total neutralizing power of lime and can increase plant grows up to 45 % over traditional limestone (Risse, 2013).

Wood ash is easily applied with con-ventional lime or manure spreading equipment. Distribution of ashes is difficult. Therefore, their possible granulation and granular solubility are studied. The effect of granulation and ammonium sulfate addition on the solubility and bioavailability of nutrients and harmful elements from peat and wood co-combustion was investigated (Pesonen and etc. 2017).

Wood ash, in particular, contains all the nutrients that plants need in almost correct proportions, excluding nitrogen, which is released into the atmosphere during combustion. Nitrogen could be added to ash fertilizers by co-granulating bio-ash, for example, with sewage sludge (Pesonen and etc. 2016). However, co-granulation has not been studied extensively.

The method to produce lightweight aggregates by granulating peat-wood ash using alkali activators is shown (Yliniemi and etc, 2016). The peat-wood ash was granulated with potassium silicate and sodium aluminate in a high-shear granulator to produce spherical granules. The study shows that by simultaneous granulation and alkali activation it is possible to increase the utilisation of ash and produce valuable products. The present paper is dedicated to granulation of wood ash using liquid manure.

MATERIALS AND METHODS

Ash samples for analysis were taken in March 2015 and February 2016 from 2 different heat boilers. For analysis ash that just came from the firebox / ash box / and one month old ashes, which have remained in a landfill in the open sky, were used. The ash which was taken from the ash boxes was produced by the boiler house on the same day.

Table 1. Results of analysis of ash samples.

Components	Simbol	Units	Sample No. 1	Sample No. 2	Sample No. 3	Sample No. 4
Antimony	Sb	mg/kg	1.3	1.27	1.25	1.31
Arsenic	As	mg/kg	3.4	3.2	3.1	3.3
Barium	Ba	mg/kg	1800	1600	1650	1670
Zinc	Zn	mg/kg	737.5	1356.1	1019.5	411.1
Mercury	Hg	mg/kg	0.03	0.03	0.025	0.027
Phosphorus	P	%	0.7	1.14	1.21	1.07
Chromium	Cr	mg/kg	25	27	25	26
Cadmium	Cd	mg/kg	2.3	3.2	2.9	2.4
Calcium	Ca	mg/kg	130000	132000	126000	128000
Potassium	K	%	2.32	3.06	2.34	1.71
Magnesium	Mg	mg/kg	22	24	25	30
Manganese	Mn	mg/kg	8	9	12	14
Molybdenum	Mo	mg/kg	1.2	1.5	1.7	1.3
Sodium	N	%	0.21	0.1	0.08	0.12
Nickel	Ni	mg/kg	32	27	28	30
Lead	Pb	mg/kg	59	79	65	72
Vanadium	V	mg/kg	29	27	26	28
Copper	Cu	mg/kg	110	90	90	75
Acidity	pH	pH	12.72	10.6	12.48	11.69

Liquid manure samples were taken from lagoons in 4 different farms. Those farms engaged in milk production and the number of cows they have between 800 and 2500th. The lagoon was mixed and then samples were taken. Four samples were taken each time. Analysis of the chemical composition of ash and liquid manure has been carried out at the Agronomic Analysis Laboratory, Jelgava. The results of the analysis are summarized in Table 1 and Table 2.

The analysis of the ash content showed that they comply with the permissible values of certain components in the natural environment determined by the legislation of the Republic of Latvia.

Table 2. Analyses of the chemical composition of liquid manure in different farms

Farms	Dry Matter, (%)	pH	Total N $N+NH_4$-N	NH_4-N	P_2O_5	K_2O	Organic
			(%), absolute dry sample				
A1	7.5	6.71	8.80	1.22	1.22	3.25	73
A2	8.6	6.96	1.94	1.71	1.22	2.68	84
A3	8.0	6.76	2.23	1.64	1.54	3.70	82
A4	8.3	7.34	8.22	1.32	1.33	3.18	76

The ash and liquid manure were mixed in a rotary drum granulator (see below Fig.1)) and granules were dried for six days at room temperature 20 C^o (see below Fig. 7).

RESULTS

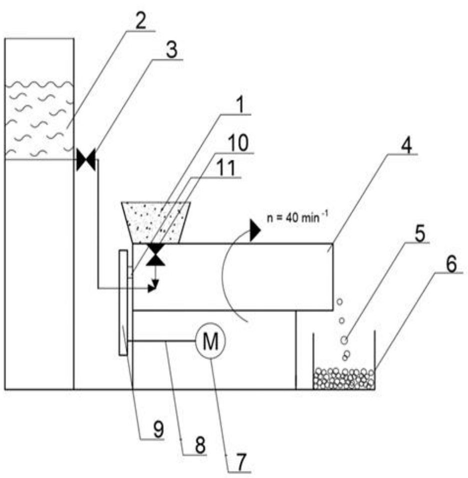
Why was liquid manure used? When analyzing various combinations the mixture of liquid manure and ash maintained the highest Ph level, which was taken as the main factor (in Table 3).

Table 3. PH reaction of ash and mixture of ash with other added liquid substances.

No.	Ash from ash boxes	Ash from the landfill	Ash + H_2O	Ash+HNO_3	Ash + liquid manure
1.	11.82	10.23	6	4.2	10
2.	11.79	10.28	5.6	4.35	9.9
3.	11.73	10.29	6.2	4.29	9.85
4.	11.84	10.27	5.9	4.22	10.1

As it can be seen in Tab. 3 Ph levels for a mixture of ash + liquid manure do not change significantly, which cannot be said about the other mixtures.

The main purpose of our research was to develop an experimental equipment that could produce ash granules, which would then be easily incorporated into the soil. The equipment scheme is shown in Figure 1.



. Ash box;
2. Liquid tank;
3. Liquid tank valve;
4. Rotating drum;
5. Granulas;
6. Tank of granulas;
7. Electric motor;
8. Axle connecting the motor with a coupling belt;
9. V-belt transmission;
10 An ash tank valve;
11. Axle connecting the drum and the coupling belt.

Fig. 1. Operation scheme of the granulation equipment

As it be can seen, the size of the granules resulting from the experiment is not the same. Their variation values (minimum and maximum lengths) are shown in Table 4.

In each mixture, the determining size granule fraction accounted for about 95% of all granules. Changing the ash - liquid manure ratio various sizes of ash + liquid manure mixture pellets were obtained. The results of the pellet size (average length and width) are shown in Tab.5 and Figures 2–6.

Table 4. Minimal and maximal sizes of granules obtained in the experiment

Ratio of ash and liquid manure	Min and max size
1000 ml and 200 ml	1mm – 5mm
1000 ml and 300 ml	1mm – 7mm
1000 ml and 400 ml	1mm – 12 mm
1000 ml and 500 ml	5mm – 32mm
1000 ml and 600 ml	10mm – 53mm

Table 5. Dependence of the average length and average width of the pellets on the ash and liquid manure ratio

No.	Ratio of ash to liquid manure ml	Pellets average length mm	Standart deviation	Pellets average width mm	Standart deviation
1.	1000 and 200	1.5	0.5	2.2	0.3
2.	1000 and 300	4.1	0.8	4.25	0.6
3.	1000 and 400	6.5	2.0	5.7	1.5
4.	1000 and 500	13.4	5.0	12.9	4.2
5.	1000 and 600	36.9	4.9	39.8	4.6

Fig.2. Pellets of mixture 1000 ml ash and 200 ml liquid manure

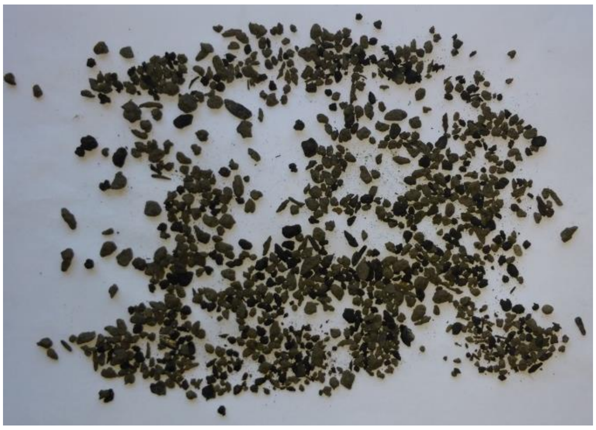


Fig.3. Pellets of mixture 1000 ml ash and 300 ml liquid manure

Fig. 4. Pellets of mixture 1000 ml ash and 400 ml liquid manure

Fig. 5. Pellets of mixture 1000 ml ash and 500 ml liquid manure

As the experimental results show, the best used ratio of the mixtures was 1000ml of ash and 200 ml of liquid manure or 1000ml of ash and 300 ml of liquid manure. In this situation, the received granule sizes were very close to the size of mineral fertilizers (Table 5 and Fig. 2-3). The dimensions coincide with NPK 9 25 25 regulations, where fertilizer grain sizes are below 1 mm 3%, from 1 mm to 6 mm, 97% and not more than 6 mm (Product specification NPK 9-25-25, 2016).

Fig. 6. Pellets of mixture 1000 ml ash and 600 ml liquid manure

Fig. 7. Pellets drying conditions

Granules of this kind can be easily incorporated into the ground using fertilizer spreaders. It should be noted that the dispersion of this type of ash granules does not smudge dust, which is observed at ash dispersion.

CONCLUSIONS

1. Biomass ash is suitable for use as a fertilizer in pean lands, which contain high amount of nitrogen, but lack phosphorus and potassium. Necessary nitrogen for plants can be added in the granulation process using liquid manure in the granulation process.
2. Granulated ash is a significiently more cost-effective alternative for ash recycling compared with unprocessed ash. Granulation prevents dust problems during transportation and application. It is possible to get granules of varying sizes using a rotating drum. The granule size depends on the ash and liquid manure ratio.
3. The experimental results showed that the best used ratio of the mixtures was 1000 ml of ash and 200 ml of liquid manure or 1000 ml of ash and 300 ml of liquid manure. In this ratio, the produced granule size was very close to the size of mineral fertilizers and it can be disseminated with fertilizer spreaders.

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