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Part 3

ASH AND SLAG HANDLING

3.5. Applications of ash and slag from power coals

3.5.4. Use of ash and slag for improving the properties of soil

3.5.4.4. The biomass ash. Waste or useful by-product?

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ABSTRACT

This paper is a short overview presenting the different areas of biomass ashes application in the agriculture and forestry. The advantages and disadvantages of biomass ashes as a source of nutrients for the plants are discussed.

INTRODUCTION

The dynamic changes on energy suppliers market have been observed in Poland during last decade. The EU policy by pressing great attention on the environment protection has great impact on the energy production sources balance. The emission CO_2 quotas enforce the power companies to invest in renewable technologies, mainly wind farms and thermal combustion of plant biomass installations. This last technology, based mainly on fluidized bed combustors, is especially developed by electrical industry. In Fig.1 Power Plant Szczecin with the fluidized bed

combustion system is presented.

Fig. 1. The fluidized bed combustion system in Power Plant Szczecin, Poland.

Parameters of the Power Plant: ”green” energy production – 440000 MWh/year, fuel consumption– 708000 Mg/year (wood chips and straw pellets), ash production – 3600 Mg/year (bottom ash), 5000 Mg/year (fly ash). In Fig. 2 a part of fuel supply system of Power Plant Szczecin is shown.

Fig. 2. The part of fuel supply system (Power Plant Szczecin, Poland).

In the last years the several installations started across Poland and some will be in the pilot project phase. The unavoidable consequence of energy and heat production, or both, based on biomass as a source material is an ash production. In the Poland recycling regulations treat biomass ashes similarly as the ashes derived from coal combustion installations. At present, the restricted lows caused, that all tonnage of produced ashes is disposed in the landfills, which generating considerable costs for the biomass plant operators. Biomass ash contains a variety of the macronutrients and micronutrients, which can be successfully used for agricultural purposes, to close nutrients recycling. Returning of biomass ashes to the locations where biomass was harvested can be regarded as sustainable options, neutral for agroecosystems.

ASHES COMPOSITION

The amount of post combustion ashes and their nutrient composition and other properties are affected by different factors. The physical and chemical properties, and then of course quantity of ash are strongly dependent on:

a) kind of biomass combusted (the plant species, the origin of plant, the plant parts used for combustion, the forms and storage of raw material);
b) combustion technology (the grate stokers, fluidized-bed combustion stokers, construction of combustion chamber and boilers, and parameters of the burning process e.g. temperature, air flow and many others);
c) cleaning technology of the flue gases stream (cyclone, filters);

d) support technology used in combustion processes (ammonia water or dolomite added to the combustion bed) – [1 - 3].

During incineration of wood and other types of plant biomass, a solid residue is formed – ash, representing about 2 % (e.g. willow wood) to 20 % (e.g. rice husks) of the input material [4]. The primary factor influence ash quality is the kind of burning material. There is agreement that the best solution is using the hard wood as a raw material. The wood ash derived from non contaminated wood contains low level of dioxins and heavy metals and may be used as a fertilizer even in the biological farming [5]. On the opposite site are located ashes from sewage sludge burn processes [6]. The quality of ashes from other sources is situated between mentioned above. In Poland, existing industrial installations burn mainly wood biomass (c. a. 80 %) and the rest is agro biomass derived from different sources. From Fig.3 fly ash from biomass could be seen.

Fig. 3. The fly ashes from biomass.

The burning technology is the secondary factor affecting the ash quality. The different kinds of installations results in multiple kinds of produced ashes. The main classifications of ash are between fly ash and bottom ash, and between ashes from fluidized bed combustion and grate stokers. In the grate stokers installations 95 % produced ashes are bottom ash and the rest are the fly ashes. The bottom ash consists of slag, sand, and unburned raw material. While, the fraction of fly ashes included small particles (white powder) reached in soluble salts and heavy metals. The production energy in the fluidized bed combustion technology completely different kind of ashes is produced than mentioned above. In this type of installation the same amount bottom and fly ash is produced. The bottom ash consists of sand, bed material, and inerts ash from the fuel, while fly ash (grey powder) is the fuel bound-ash with fragmented sand [3]. The data presented in table 1 show great variation in chemical composition (mg/kg d.m. of ash) depending on the type of ashes. This data derived from the greatest data base in Europe [7], which included observation from different type of grate stokers, filters, cyclones and the fuel materials. Fly ashes contain high concentrations of cadmium, copper, chromium, lead, and arsenic and usefulness of this kind of ashes as a fertilizer is very limited. The concentration of heavy metals in the fly ashes produced in the fluidized bed combustion installations generally showed great variation but in new type generators do not exceed level typical for the standard fertilizers. However, the proportion *Mg* and *Ca* to heavy metals is greeter.

Table. **Limited concentrations of elements in ashes produced from different kinds of biomass in case of various combustion technologies, g/kg d.m.**

Element	All ash			Bottom ash			Fly ash			Ash mixture
	min	max	$\bar{x}$	min	max	$\bar{x}$	min	max	$\bar{x}$	$\bar{x}$
P	2	409000	15311	11	409000	26073	2	45025	9952	19912
K	24	465000	96058	142	336000	58059	234	417960	207918	60844
Ca	1	683356	219370	60	590000	269906	7	311959	129953	204585
Mg	98	160000	28467	2232	160000	38871	1	46985	17045	30795
Na	297	124715	6416	672	108000	6351	337	36735	9078	8532
S	150	140889	22753	150	137000	7511	2279	128540	45314	14478
Pb	1	48950	694	1	1890	63	12	6989	1066	137
Zn	8	113849	6436	8	3769	416	163	38916	12064	1560
Cd	1	451	40	1	24	2	1	155	57	10
As	1	130	15	1	31	7	2	40	13	24
Cl	2	467218	31014	4	18330	1632	830	351915	108096	3197

BIOMASS ASHES AS A NUTRIENTS SOURCE

The benefits of use ashes as fertilizer are obvious. The recycling of the residues in agriculture can contribute to realize nutrient cycles and reduce the necessity of commercial fertilizer application [6, 8]. This has special importance for P, since the P resources are strongly limited worldwide [9]. Ashes from combustion of biomass are the oldest mineral fertilizer. Biomass ashes are nearly free of nitrogen but contain P and other nutrients needed for plant nutrition [10]. Ash from bioenergy plants has mainly been considered as liming material because of its high content of *Ca*, although the *Mg*, *K* and *P* content may also be of importance [11].

The most important disadvantages are:

a) ashes are not complete fertilizers – lack of nitrogen;

b) Phosphorus is present in the non soluble forms in the natural soil conditions;
c) nutrient concentration is low in proportion to heavy metals;
d) high amount of undesirable inerts;
e) low consistency;
f) mineral sources used for production of fertilizers are cleaner and more reliable;
g) lack of interest of fertilizer industry – [3] .

ASHES UTILIZATION AS FERTILIZERS

Ashes can be used directly as a fertilizer or as an initial material for fertilizers production. Positive effects of non contaminated biomass ashes in forest and agroecosystems were found in different studies [12, 13]. The influence of ashes on the biomass yield, growth dynamic, leaching, pollutant content, photosynthetic capacity, and soil physical, chemical, biological and microbiological properties were tested [14 - 18]. Wood ash is applied to forest soils to alleviate nutrient depletion and soil acidification, either alone or in combination with N fertilizers. Wood ash is also applied as lime replacement, providing base cations to increase soil *pH*. Furthermore, biomass ashes can also be used as liming agents, and can stimulate microbial activities in the soil [19, 20]. Also, agrobiomass ashes can be used as the potassium fertilizers (Fig. 4) – [21].

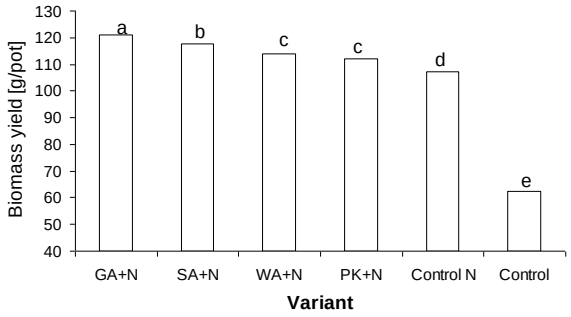

Figure 4. Yield of *Festulolium* in pot experiment depending on different kind of ashes in combination with nitrogen – N (GA – grain ash, 49 g K/kg d.m.; SA – straw ash, 32,7 g K/kg d.m.; WA – wood ash,13,4 g K/kg d.m.; PK – commercial fertilizers). The means indicated by the same letter do not differ significantly according to Tukey test at p=0,05.

APPLICATION WAYS

There are many possibilities to input ashes to the soil. A number of problems are associated with the application of loose ash. The loose ash: a)is difficult to handle, b)increased health risks, c)is difficult to spread by machines, d) has a greater potential for deleterious effects to ground vegetation, particularly to the cover and species of moss communities [5]. Hence, processing methods (grinding, palletizing, and granulating) are in common use, which modifying also the availability of nutrients [22 - 24]. Generally, the plant availability increases with decreasing particle size of the ash. Pellets and granulates should be used only for long term fertilizing. Another way to use ashes is blending with organic wastes for instance sewage sludge. Ashes may be added to the compost to stabilize the composting process (temperature, microbiological activity). The mixtures of ashes with limestone may be also use as a soil improver.

CONCLUSIONS

The no contaminating biomass ashes should be treated as a by-product not as a waste dumped in the landfills. The ashes are a source of nutrients (*P, K, Mg* and *Ca*) which should be return to the places where the biomass was harvested, to close natural recycling of minerals. The possible areas where the ashes can by apply are: forestry and industrial and energetic crops plantations. The restricted government low regulations should be changed. Moreover, greater public and landowners acceptance to use ashes, not only in forestry, but also for agricultural purposes is necessary.
Also: *Ni*, *Co*, *Cr* and *Cu*

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