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STUDY ON THE CHARACTERISTICS OF WASTE WOOD ASH

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ABSTRACT

Minimization and utilization of industrial wastes as secondary raw material resources is essential to achieve sustainable technologies. This work presents the results of a study of the properties of ash resulting from combustion and industrial processes in the complex "Svilosa" in Svishtov. Using appropriate analysis and physico-chemical techniques, chemical and phase composition of the generated ashes, the main crystal phases which are formed in the realization of industrial technologies are identified. The generated wood ashes are alkaline in nature and contain essential nutrients needed for development of different plant species. The survey makes a recommendation to use industrial wastes generated by the industrial complex to obtain composite solid mixtures, suitable for use as soil improvers in agriculture.

Keywords: wood ash, soil improvers, loss of ignition (LOI), X-ray diffraction (XRD) analysis, light optical microscopy (LOM).

INTRODUCTION

Industrial production of the "Svilosa" company in Svishtov generates different types of wastes. One of the largest of them is wood ash separated in the utilization of the waste from bark, wood chips, sawdust and cuttings as an energy resource [1]. So far, the annual quantity of wood ash generated is about 10 000 tons per year [2], but with the expansion of production its volume is expected to grow almost twice. As a result of the oxidation processes during combustion the generated wood ash retains the overall composition of the mineral nutrients contained in the waste wood with the exception of nitrogen compounds, which are mainly released into the gas phase. Wood ash, in accordance with national legislation [3] refers to code 10 01 99 subgroup 10 01 (wastes from power stations and other combustion installations) of Group 10 (wastes from thermal processes). Nutrient mineral elements contained in the form of fixed substances are relatively stable during the burning thermal treatment. These elements are in the same proportions as they were in the structure of the wood pulp, which is a prerequisite for a good methods and technologies for use in the chemodynamic cycle of the elements in the soil systems. Nitrogen compounds from the pulp in the combustion process are degraded and released in the atmosphere as a waste's gas mainly in the form of oxides [2].

In most cases, ash from the combustion of plant's wastes does not contain heavy metals and other toxic elements in concentrations that could lead to secondary contamination of soil and agricultural products for recycling as a soil improver. Typically, the reaction of the eluate of wood ash in water or electrolyte solutions is alkaline and it defines them as secondary raw material resources suitable for the production of acidic soil improvers, where necessary, regulating the pH of the soil solution or soil structure with buffer components and certain food items in soils [4]. The aim of this paper is to characterize the chemical and phase composition of wood ash obtained from the burned wood waste of the pulp production in the industrial complex "Svilosa", using different methods and techniques in order to prove that such types of ashes could be used as a secondary raw material for production of soil improvers, contributing to the reduction the quantity of generated industrial waste and achieving greater sustainability and efficiency of the currently used technologies.

EXPERIMENTAL

The study used an average monthly sample of wood ash from the regular industrial production, as required by the standard [5]. It was subjected to chemical analysis to determine the available forms of nutritional and toxic elements. The loss on ignition (LOI) of the ash was determined at temperature of 800°C and time of ignition – 1 h as recommended in [6, 7].

The phase composition was analyzed with X-ray diffraction (XRD) carried out with an X-ray diffractometer TUR–M62 with Cu-anode X-ray tube. Light optical microscopy (LOM) analysis was carried out with the polarizing microscope "Laboval-pol-a" in the 160x and 640x magnification. Observations were made on immersion preparations in passing light.

RESULTS AND DISCUSSION

The results of the chemical analysis and some indicators in the monthly sample of wood ash from the "Svilosa" company are presented in Table 1.

The results show that the wood ash is clearly of an alkaline nature (pH of aqueous extract = 12.61). This clearly defines the high potential of this type of ash as a raw material resource for the production of acidic soil improvers. Other indicators like free moisture content, electrical conductivity, organic matter content and overall nutritional and toxic elements and their mobility in aqueous solutions also confirm that the wood ash is a suitable for soil improvers production.

The LOI of the wood ash is 19,6 %. That value is higher than the values for the three limits which determine the three categories at loss of ignition, described in [7] and are related to use of ash in concrete production. The established values also determines the wood ash as rich in non-burned carbon, which most probably is due of the content of non-burned wood particles and coals.

Fig. 1 presents the diffractogram of the wood ash from the XRD analysis. Interpretation of the data was carried out by comparing the experimental data with the database of the International Centre for Diffraction Data.

The obtained data confirme the presence of several major crystalline phases. The predominant crystalline phase is calcite - $CaCO_3$, accompanied by smaller quantities of quartz - SiO_2, potassium and calcium carbonate (fairchidite) - $K_2Ca(CO_3)_2$. The presence of other characteristic intensities show that the studied wood ash

Table 1. Results for the properties and composition of the wood ash sample.

Studied indicator		Result
Moisture, %		0,40
Organic matter (dry material), %		0,68
pH /H2O/, Ph		12,61
Conductivity, Ms		10,95
Total content of macro elements (dry matter), %	N	0,040
	P_2O_5	0,722
	K_2O	2,39
	CaO	52,0
	MgO	1,32
Content of soluble macro elements (dry matter), mg/100g	$N–NO_3$	1,05
	$N–NH_4$	0,07
	P_2O_5	trace
	K_2O	209
	CaO	1277
	MgO	trace
Contents of other moving soluble ions (dry matter), mg/100g	Cl^-	69
	SO_4^{2-}	39
	Na^+	38
Total content of heavy metals (dry matter), mg/kg	Cd	1,11
	Pb	99,7
	Cr	23,0
	Ni	16,1
	Cu	129
	Zn	133
	As	11,3

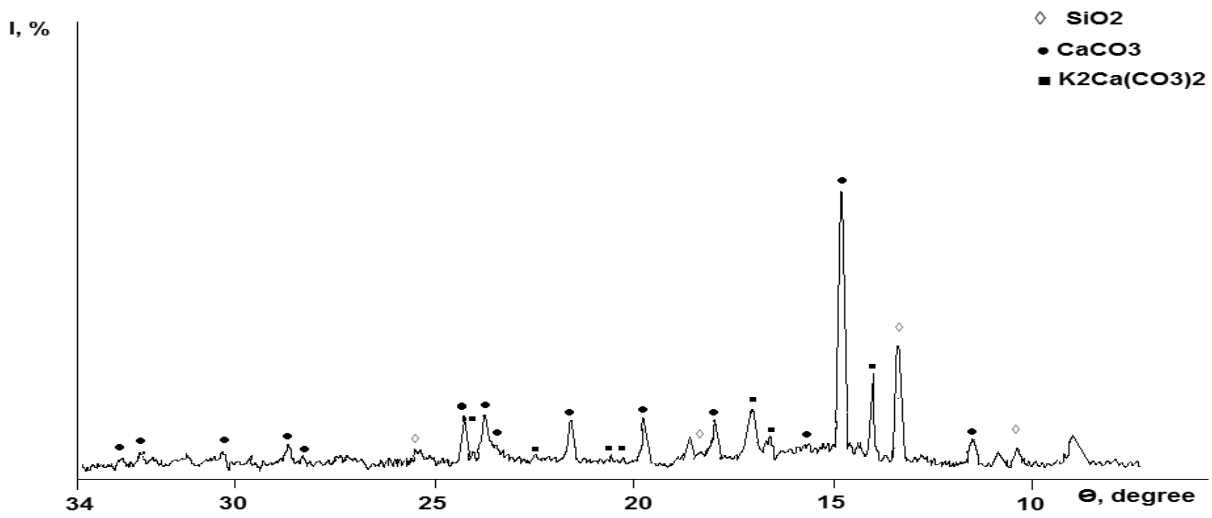

Fig. 1. XRD pattern of wood ash sample.

contains other crystalline phases, but due to low content and small particle sizes the observed diffraction intensities can not be reliably identified.

The plain microscopic observation were found a dominance of the crystalline phase, whit optical characteristics corresponding to calcite. The presence of crystalline phase with gray interference colors are characteristic of quartz. There are very fine crystals, which in many cases are aggregated to form larger entities - agglomerates. Fine crystals with dimensions up to 1 - 2 μm, and the agglomerates formed from them are in the range of nanomaterials (0.02 – 0.04 mm).

The observation with crossed polarized light (+N) found that the sample has a crystalline character, but single grains of isotropic amorphous phase are also seem. Furthermore, crystalline phases owing to much larger inclusions of not completely burned wood are identified. The fine dispersion character of the particles of wood ash show that this type of industrial waste is suitable for production of soil improvers, which will likely be characterized by high sorption capacity.

The introduction of regulations for utilization of wood ash as a soil enhancer for the acidic component or composites of more complex enhancers for

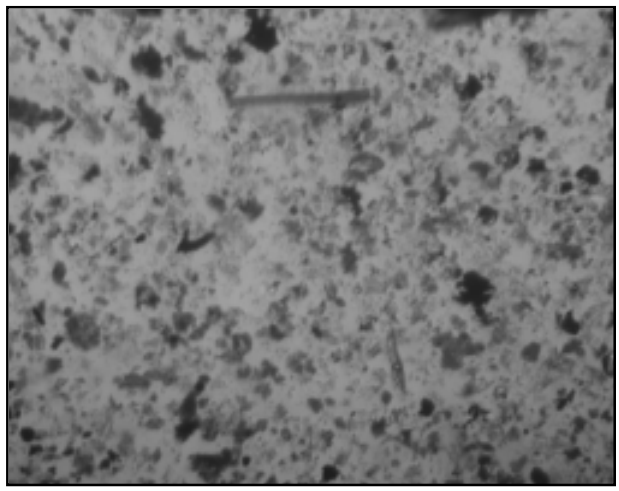

Fig. 2. Morphology of wood ash in plain polarized transmitted light.

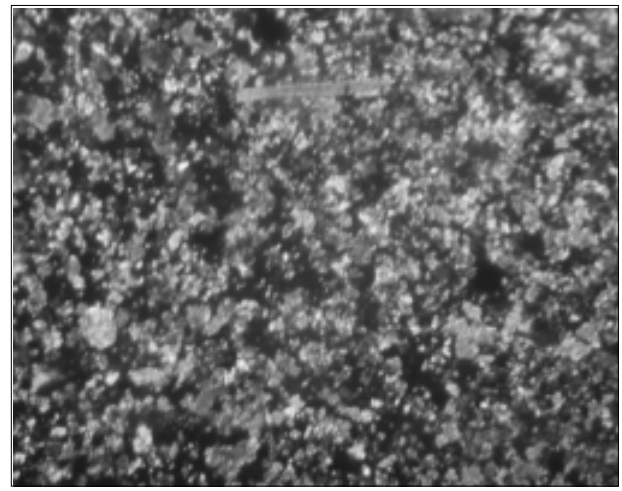

Fig. 3. Picture of wood ash with in cross-polarized transmitted light.

different types of soil will help to achieve positive changes in several directions:

• Improving the environmental situation in the industries generating ash from the combustion of wood waste and compliance with the principles of sustainable development;

• Increasing of the productivity of different types of soils and achieving greater economic efficiency and sustainability of the agrosystems [8-10];

• Reduction of the amount of industrial waste generated and reduction of the imports of different fertilizers for agriculture.

CONCLUSIONS

On the basis of the data obtained from studied composition, structure and properties of the wood ash, the following main conclusions can be made:

• The chemical composition of wood ash match the needs of different plant species and soil types on the content and ratio of nutrients;

• The content and mobility of toxic elements in the wood ash is in full compliance with the regulatory requirements to protect soil quality and agricultural production;

• The value for LOI of the wood ash shows high content of non-burned carbon;

• The LOM and XRD analyses confirm that the basic crystal forms in wood ash are $CaCO_3$, SiO_2 and $K_2Ca(CO_3)_2$, which determine the nature of the alkaline extracts in water and wood ash is an attractive material for neutralizing acidic soil;

• Proven is the fine dispersion nature of the particles of wood ashes, some of which are nanosized, suggesting a high sorption capacity and the possibility of using wood ash as a component of the composite soil improvers;

• The introduction of regulations for the use of wood ashes as secondary raw material resources can accelerate for their utilization.

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