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Characterization of biomasses in the southern Italy regions for their use in thermal processes

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HIGHLIGHTS

- Use of bioenergy sources as an alternative to fossil.
- Physical–chemical properties for an advanced use of the sustainable resource.
- Composition of biomass for the use of this fuel for energy purposes.
- Characterization of different types of biomass found in the regions of the southern Italy.

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ABSTRACT

The attention regarding bioenergy sources, such as biomass, as an alternative to fossil fuels has increased tremendously over the past few years consequently to the problems related to global warming.

For the using of biomass as fuel is very important the basic knowledge of its physical–chemical properties for the using of the sustainable resource.

The identification of biomasses in terms of both quantification and characterization of the chemical composition of biomass is a fundamental step for the use of this fuel for energy purposes. There are many differences between the various types of biomass; firstly, the moisture, the chemical composition and in particular that of the ashes, and the content of inorganic substances.

The elements mainly present in biomass, in decreasing order of abundance are: carbon, oxygen, hydrogen, nitrogen, calcium, potassium, silicon, magnesium, aluminum, sulfur, iron, potassium, chloride, sodium and manganese. In addition, compared to coal, the chemical composition of biomass is significantly different, in particular the biomasses are highly enriched in hydrogen, manganese, potassium, phosphorus, chlorine, calcium, sodium and magnesium, as well as in terms of moisture and volatile substances compared to coal, while result with a lower ash content, iron, carbon, nitrogen, sulfur, and silicon.

The purpose of this work is the quantification and characterization of different types of biomass found in the regions of the southern Italy with similar soil and same climatic conditions, at the end of their use in mixtures in an optical of build several ultrashort bioenergetical chains. Experimental results have shown that the heavy metal content is significantly lower in the fly ash than the bottom ash, and therefore, their mixture may be used as a soil improver to maintain the cycle of nutrients in soils.

1. Introduction

Power and thermal energy production from biomass gasification can represents a good solution in particular for rural areas where the retrieval of biomass is not a problem and at the same time electricity and thermal energy are required, such as near the forested areas at the end to preserve it by fires [1].

The understanding of the ashes thermal behavior, properties and their environmental impact in the long term can represent a high risk for the development of a scenario for the power generation, heat and liquid and gaseous biofuels from biomass that need to be evaluated and studied. Using ash as a byproduct of thermochemical processes is limited by the presence of heavy metals and others inorganic compounds formed as a result of the cracking reactions. The most interesting materials considered for the paper are substantially represented by solid biofuels derived from various manufacturing processes, in order to have a range of characterized matrices available that are present in the same production

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Nomenclature

UNI EN	National Agency of unification
CEN	European Committee for Standardization
ISO	International Organization for Standardization
DIN	Deutsches Institut für Normung
ASTM	International Standards Worldwide
HHV	Higher heating value
LHV	Lower heating value
AI	Alcaline Index
$R_{a/b}$	acid–base ratio
m (g)	material weight expressed in gram (g)
Q_i (J)	is the sum of heating value non product from the combustion (i.e. metal wire, capsules and other materials)
Δt (°C)	temperature increase measured in the system calorimetric
F (% p/p)	condensed water in the bomb calorimeter, expressed as % by weight of the sample determined by weighing or calculated on the basis of the reaction stoichiometry of the hydrogen contained in the sample and moisture
24.41 (J/g)	factor for the latent heat of evaporation of water
C (J/°C)	thermal capacity of the system. Is determined by burning in the same system a known amount of a reference substance of which is already known to the HHV
HPLC	High Performance Ionic Chromatography

areas. In several cases the combination of some metals with porous char has a positive effect respect to the syngas cleaning [2].

The main biomass examined are:

- Food residues.
- Forestry residues.
- Residues from the manufacture of wood.

In particular, samples that fall under neither type, identified and partly collected for characterization are:

- olive residues;
- pruning:
  - olive;
  - grapevine;
  - other overall;
- almond shells;
- apricot kernels;
- Residual forest from maintenance woods:
  - cerris;
  - oak;
- sawmill waste;
- wheat straw;
- corn residue

2. Experimental work

2.1. Feedstock characterization

For the classification of biofuels taken into account, reference was made to the UNI EN 14961 norms "Specifications and Classes Solid Biofuels, General Classification."

The classification is based on the nature and origin of biofuels useful to evaluate the material for applications in energy use. The analysis were carried out according to the UNI EN issued by CEN TC 335 to supplement and replace other standards (ISO, ASTM, TAPPI, etc.). In particular:

- Dry matter percentage (DM%).
- Content ash content.
- Determination of macro-elements: Al, Ca, Fe, K, Mg, Na, P, Si.
- Determination of trace elements Cd, Cr, Ti, Cu, Ni, Pb, Zn.
- Lower and Higher Calorific Value (q v, net).
- Volatile Substance% (volatiles).
- Fixed Carbon% (Fix C).
- Elemental analysis (C, H, N and O).
- Content of Cl, S.
- Percentage of extractives, hemicellulose, cellulose and lignin.

These data are important in the realization of mass and energy balances and in the preliminary estimate of any possible inorganic contaminants, such as HCl, H_2S, NH_3 of the raw-gas, fly ash and for the management of the ashes of the queue obtained as a byproduct of the thermochemical processes.

At this stage, parameters such as bulk density and particle size distribution have not been determined; these measures, given their peculiarities, will be carried out on batches of materials intended for use in implantation.

The possible use of a mix of biomass must be properly assessed, taking into account the ash content of each fraction and its composition since they can create conditions in which there is formation of ash that melting at lower temperatures resulting in softening and melting induced problems.

Given, however, that the ash content, and their composition depends only on the type of biomass, especially from the areas and the land in which the plant is cultivated it follows that also the thermal behavior of the same is affected; the determination of the temperature range ash melting will be determined on lots of biocombustible actually used in the plant which will be built under the project.

Characterization are listed below:

Table 1 shows the methods that are used for biomass characterization. For each one samples and their preparation was performed in the laboratory according the UNI EN 14780 with manual division technique and then reduced with a knife mill with a sieve less than 1 mm.

3. Methodology

3.1. Higher heating value

Higher heating value is the main parameter for the characterization of biomaterials for the conversion for the energy recovery.

The measure was carried out with calorimetric method in adiabatic condition with an IKA C 4000 Mahler's bomb.

The international methodology used refers to standards ISO 1928, DIN 51900, ASTM 240 D. This methodology requires the measure of a fixed quantity of material that is burn in oxygen atmosphere at 30 bar. Pure oxygen is in excess respect to the stoichiometric quantity required for the combustion at the end to obtain the complete combustion of the solid combustible. The heat developed by the combustion is transferred to the water bath of the calorimeter vessel thereby increasing its temperature. To the increase of temperature is possible to evaluate the higher heating value and lower heating value, HHV and LHV respectively, as you can see in the equations below:

$$\mathrm{HHV}\left(\frac{J}{g}\right) = \frac{(C \times \Delta t) - Q_i}{m} \quad (1)$$