THE BIOMASS RESEARCH CENTRE LABORATORY FOR BIOMASS CHARACTERIZATION

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ABSTRACT: The use of renewable energy sources is becoming important to reduce global warming and to provide fuel supply. Biomass fuels have to be used in a clean and more efficient way; so, it's important to know their chemical and physical characteristics, in order to choose the best energetic conversion process.
The Biomass Research Centre, founded in 2003 by the Italian Ministry of Environment and the University of Perugia, realized a laboratory to study physical and chemical characteristics of biomass. Laboratory aims to create a database for Italy, with data of ultimate analysis, proximate analysis and lower calorific value, in compliance with Italian Standard UNI, European CEN/TS and American Technical Norms ASTM. The main samples analyzed are residual and forestry biomass, collected from Umbria Region, and solid biofuels such as pellets and chips. Archive and experimental data are periodically updated and increased.
Keywords: Biofuels standardisation, Biomass composition, Biomass characteristics

1 INTRODUCTION

EU and Italy, with Kyoto Protocol subscription, are involved in the greenhouse gases reduction; renewable energies have an important role in this process and in particular biomass could contribute in a significant way.

Biomass represents a complex system for solar energy accumulation by means of clorophyllos photosyntesis, in which the atmospheric Carbon Dioxide is transformed in organic substance.

Biomass could be employed for energetic conversion by means of different processes, such as bio-chemical or thermal-chemical ones. The process choice depends on the biomass characteristics; therefore an important step in the conversion systems study is the evaluation of the biomass availability and its energetic, physical and chemical characteristics.

Biomass could be characterized knowing the main energetic parameters, such as Higher Heat Value (HHV) and Lower Heat Value (LHV), chemical characteristics (Carbon, Hydrogen and Nitrogen content), physical parameters (Moisture, Ash and Volatile compounds content).

In 2003 the Italian Ministry of Environment found the Biomass Research Centre (CRB), in order to create a scientific reference organism about energetic biomass employment. Among its activities, CRB realized a Laboratory for the energetic and physical – chemical characterization of biomass and biofuels.

The Laboratory is active since February 2005; many analysis were carried out, on different kind of biomass; results were organized in a Data Base developed by the Centre staff.

In the present paper the analysis carried out in the CRB Laboratory and the related methodologies, in compliance with International and Italian Standards for biomass characterization, are described.

Moreover, as an example, some experimental data on woody biomass are presented; results are also compared with data from Literature; an evaluation of the measurement repeatability is also given.

Finally the Data Base for measurements results organization is described.

A general view of the Laboratory is shown in Fig. 1.

Figure 1: A general view of CRB Laboratory

2 ANALYSIS AND INSTRUMENTS

CRB Laboratory for biomass characterization is equipped with instruments which allow to realize the following analysis:

- Proximate Analysis (Moisture, Ash and Volatile Compounds content);
- Ultimate Analysis (Carbon, Hydrogen and Nitrogen content);
- Higher Heat Value and Lower Heat Value;
- Pellet durability.

Laboratory is equipped with the following instruments:

- Mill Retsch SM 2000 for the sample preparation;
- TGA 701 LECO for Proximate Analysis (Fig. 2);
- Truspec CHN LECO for Ultimate Analysis (Fig. 3);
- Calorimeter AC 350 LECO for HHV measurement (Fig. 4);
- Lignotester New Holmen Tester TekPRO for pellet durability.

The main instruments characteristics are reported in Table I, II and III.

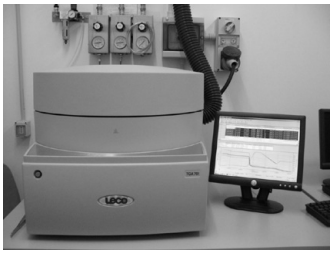

Figure 2: TGA 701 LECO for Proximate Analysis

Tab. I: TGA 701 Specifications
Sample Size: 5 grams (maximum)
Number of Samples: max 19 (+ 1 reference)
Precision: ±0.02% RSD
Balance Resolution: 0.0001 g
Oven Temperature: Ambient (minimum)
Temperature Control
Minimum: 100°C, Maximum: 1000°C
Accuracy: 2% of set point or ±2°C;
Maximum Ramp Rate
Ambient to 104°C: 15°C/min, 104/1000°C: 50°C/min
Gas Pressure : Air: 45 psi (3.1 bars)
Nitrogen: 35 psi (2.4 bars)
Oxygen: 35 psi (2.4 bars)

Figure 3: Truspec CHN LECO for Ultimate Analysis

Tab. II: TruSpec CHN Specifications
Range
Carbon: 50 ppm or 0.005% to 50%
Hydrogen: 200 ppm or 0.02% to 50%
Nitrogen: 80 ppm or 0.008% to 100%
Precision
Carbon: 0.3 ppm or 0.5% RSD
Hydrogen: 100 ppm or 1.0% RSD
Nitrogen: 40 ppm or 0.5% RSD

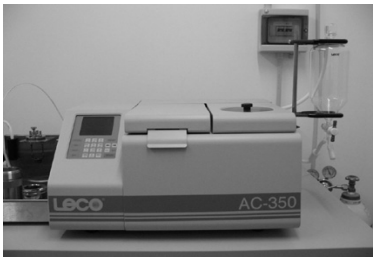

Figure 4: Calorimeter AC-350 LECO (HHV)

Tab III: Calorimeter AC 350 Specifications
Method: Isoperibol Jacket
Nominal Sample Weight: 1 g. (0.6 g. - 1.4 g.)
Range: 6-15 kBTU/lb. for 1 g. sample
Precision <0.05% RSD (Benzoic Acid)
Resolution: 1 BTU/lb. 1 kJ/kg. 0.1 CAL/g.
Temperature Measurement:
Resolution: 0.0001°C
Room Temperature: 13°C - 33°C

3 MEASUREMENTS METHODOLOGIES

All the analysis are carried out in compliance with International or Italian Standards for biomass characterization.

Samples are collected in compliance with norms reported in table IV [1, 2, 3, 4].

Proximate analysis is carried out in observance of methods defined in table V [5, 6, 7, 8] for Moisture and Ash content, while Volatile matter is determined in compliance with Italian Standard UNI 9903-8 [9].

Ultimate analysis is carried out in compliance with ASTM D-5373 [10].

In compliance with UNI 9017 [11], HHV value is measured and LHV_{db} is calculated by means of the following relation:

$$LHV_{db} = HHV_{db} - 9 * 2.398 * H_{db}$$

Table IV: Method for sample preparation

Analysis	Method
Sample preparation	pr CENT/TS 14778-1
	pr CENT/TS 14779
	pr CENT/TS 14780
	UNI 9903-3

Table V: Determination of moisture and ash content

Analysis	Method
Moisture	CENT/TS 14774-1
	CENT/TS 14774-2
	CENT/TS 14774-3
Ash	CENT/TS 14775

4 EXPERIMENTAL DATA

The classification of the samples examined by the Biomass Research Centre was based on a scheme developed by Comitato Termotecnico Italiano (CTI). It classifies biomass basing on nature and origin in the following main groups: woody biomass, herbaceous biomass, fruit biomass, biomass blends and mixture, waste, aquatic biomass.

Samples examined since its institution by the CRB Laboratory belong to all the mentioned categories, but woody biomass samples are more numerous; therefore, as an example, results related to woody biomass are reported in the following figures, distinguishing Poplar, Black Locust and Vines pruning samples.

Moisture values are in the range 30-50 % for Poplar, in the range 7-80% for Black Locust and 26-44 % for Vine pruning; Ash content is in the range 2–5 % for Poplar, 2-10 % for Black Locust and 2-5% for Vine pruning; Volatile compounds are in the range 84-88% for Poplar, 80-88 % for Black Locust and 80-93 % for Vine pruning.

Carbon content varies in the range 50-60 % for Poplar, 48-55% for Black Locust and 47-66 % for Vine pruning; Hydrogen content varies in the range 6-9 % for Poplar, 6-8 % for Black Locust and Vine pruning; Nitrogen content varies in the range 0.1-2 % for Poplar, 0.3-4 % for Black Locust and 0.4-1 % for Vine pruning.

HHV is in the range 20-25 MJ/kg for Poplar, about 20 MJ/kg for Black Locust and in the range 18-21 MJ/kg for Vine pruning while LHW is in the range 18-22 MJ/kg, about 18 MJ/kg and in the range 17-20 MJ/kg.

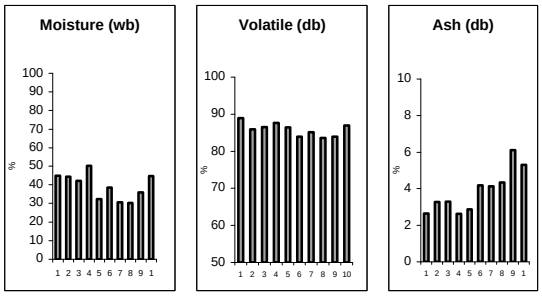

Figure 5: Proximate Analysis of Poplar samples

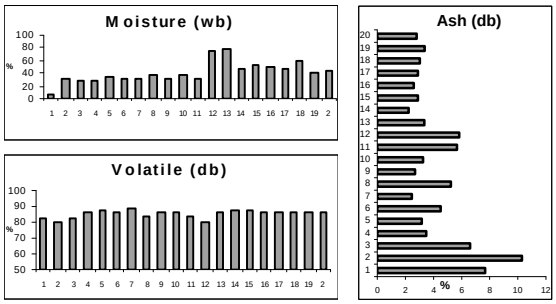

Figure 6: Proximate Analysis of Black Locust samples

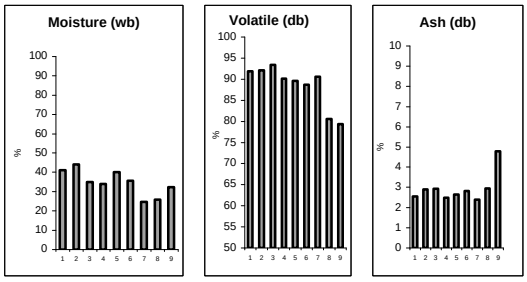

Figure 7: Proximate Analysis of Vine pruning samples

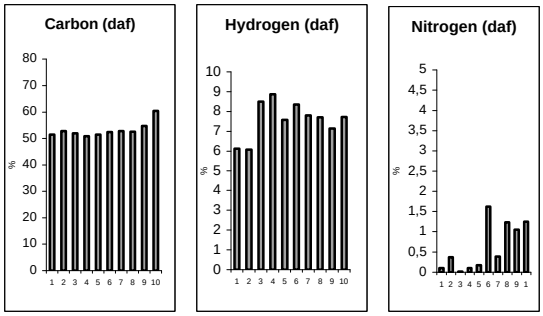

Figure 8: Ultimate Analysis of Poplar samples

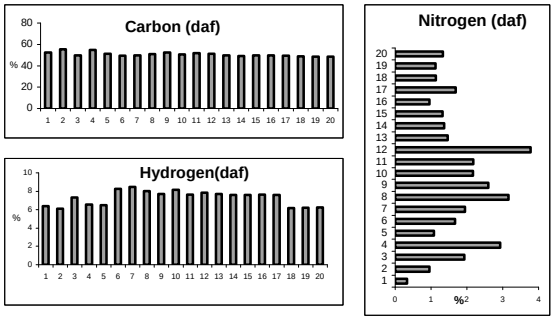

Figure 9: Ultimate Analysis of Black Locust samples

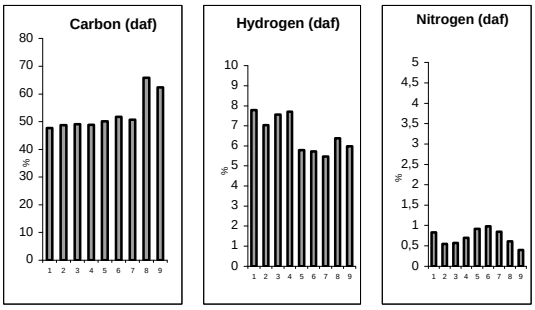

Figure 10: Ultimate Analysis of Vine pruning samples

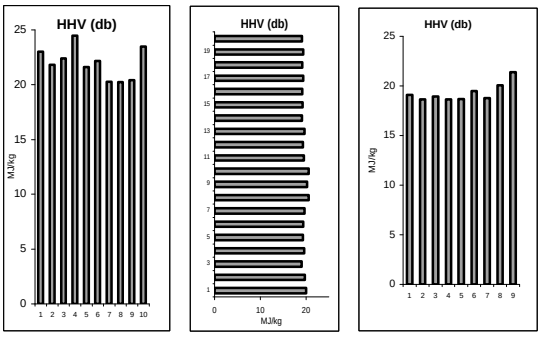

Figure 11: HHV of Poplar, Black Locust and Vine pruning samples

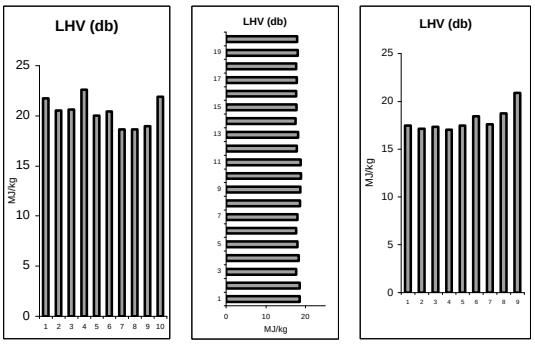

Figure 12: LHV of Poplar, Black Locust and Vine pruning samples

All results were compared with data from Literature [13, 14]; a good agreement was found (Table VI and VII).

A statistical analysis of the results was carried out in order to evaluate the measurements repeatability. Two types of woody biomasses were used, olive pruning and bamboo. Twenty tests were made for each sample and for each group of analysis. Home made software was developed to evaluate the standard deviation and the relative standard deviation (RSD) of the results. The same software was used to estimate the minimum number of necessary repetitions to have the lowest RSD value.

5 DATA BASE

A data base for data collection was implemented, in order to record all measured data.

Each record is divided into three parts: in the first one the sample characterization is done (identifying code, biomass group, sample description); in the second one the sample origin is recorded (site, address of the

supplier, quantity, sample preparation description); in the third one results of analysis are reported.

Data can be looked up with a research key (i. e. for kind of biomass, origin, CHN range contents, C/N ratio, Moisture range values, etc.).

Table VI: Results for Poplar samples and comparison with [13, 14]

Parameter	CRB laboratory	Literature data
Moisture (% wb)	30.17 – 50.13	7.60 – 9.60
Ash (% db)	2.620 – 6.120	1.80 – 3.40
Volatile (% db)	83.58 – 88.96	73.6 – 74.4
FC (% db)	7.690 – 12.10	14.3 – 16.5
HHV (MJ/kg)	20.25 – 24.48	18.4 – 20.7
LHV (MJ/kg)	18.65 – 22.62	18.0 – 19.3
C (% daf)	50.90 – 60.41	49.2 – 49.6
H (% daf)	6.080 – 8.870	7.20 – 8.00
N (% daf)	0.100 – 1.620	0.10 – 0.20

Table VII: Results for Black Locust samples and comparison with [13, 14]

Parameter	CRB laboratory	Literature data
Moisture (% wb)	7.010 – 79.20	-
Ash (% db)	2.220 – 10.29	0.800
Volatile (% db)	79.85 – 88.38	80.90
FC (% db)	8.450 – 16.05	-
HHV (MJ/kg)	19.06 – 20.06	19.71
LHV (MJ/kg)	17.50 – 18.92	18.46
C (% daf)	48.54 – 55.45	51.10
H (% daf)	6.120 – 8.460	5.750
N (% daf)	0.330 – 3.780	0.570

Table VI: Results for Vine pruning samples and comparison with [13, 14]

Parameter	CRB laboratory	Literature data
Moisture (% wb)	25.84 – 44.01	8.800
Ash (% db)	2.390 – 4.780	2.300
Volatile (% db)	79.38 – 93.40	72.70
FC (% db)	2.170 – 16.48	16.20
HHV (MJ/kg)	18.65 – 21.38	18.57
LHV (MJ/kg)	17.03 – 20.09	-
C (% daf)	47.72 – 65.83	50.90
H (% daf)	5.740 – 7.780	7.010
N (% daf)	0.400 – 0.980	0.430

6 CONCLUSIONS

The use of renewable energy sources is becoming important to reduce global warming and to provide fuel supply. With regard to the utilization of biomass as an energy source, the investigation of chemical and energetic characteristics of biomass fuels is important in the more suitable energy conversion technology choice.

The Biomass Research Centre, founded in 2003 by the Italian Ministry of Environment and the University of Perugia, realized a laboratory to study physical and chemical characteristics of biomass. CRB Laboratory is equipped with instruments which allow to realize the following analysis: Proximate Analysis, Ultimate Analysis, HHV, LHV and Pellet durability.

Samples examined by the CRB Laboratory belong to different categories, but woody biomass samples are more numerous; therefore, as an example, results related to woody biomass are reported. These results were compared with data from Literature and a good agreement was found.

A data base for data collection was implemented, in order to record all measured data.

7 NOMENCLATURE

CRB: Biomass Research Centre;
wb: wet bases;
db: dry bases;
daf: dry ash free;
FC Fixed carbon (%)
HHV: Higher Heat Value (MJ/kg);
LHV: Lower Heat Value (MJ/kg).
RSD: Relative Standard Deviation

8 REFERENCES

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