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# COMPOST STREAM AS A POTENTIAL BIOMASS FOR HUMIC ACID PRODUCTION: FOCUS ON COMPOST SEASONAL AND GEOGRAPHICAL VARIABILITY*

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## Abstract

Compost is a voluminous stream rich in humic and fulvic acids, which may be recovered as high-added value compounds. These soluble bio-based lignin-like polymeric substances (SBO) can be extracted through a completely green process developed at pilot scale, whose main core is the hydrolytic route in aqueous solutions at relatively mild temperature (< 140 °C) at ACEA Pinerolese Industriale premises. Due to their chemical-physical properties, the SBO compounds can be used with advantage for myriads of industrial applications, from the formulation of detergents to the production of agriculture bio-stimulants, answering the increasing demand for bio-compound utilization. In view of LIFECAB project (LIFE16 ENV/IT/000179), the characterization of starting materials and the derived compost has been performed over four seasons and over three European countries (Italy, Greece ad Cyprus). In view of establishing a relationship between SBO molecules and compost properties, this work is a challenging opportunity for assessing the compost variability and its temporal evolution during the composting process. Analyses of pH, salinity, total carbon, total nitrogen and C/N ratio, critically assessed by means of a statistical approach, provide important information about compost composition according to the season and to the local environmental conditions.

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## 1. Introduction

Compost is rich in humic compounds, which can be extracted with success through a hydrolytic process (Montoneri, 2017). Therefore, compost represents an important source of soluble new bio-based products (SBO), which have potential use in several fields, from the chemical industry to agriculture and animal husbandry. The SBO specific feature is the possibility of replacing fossil derived products, whose production has a significant environmental burden in terms of resource depletion, emissions and water pollutants. In fact, SBO can be efficaciously extracted by compost derived from both municipal biowaste and green residue, fulfilling the guidelines reported in the Directive 2008/98/CE (EU, 2008) concerning the proper management of waste flows in accordance with the circular economy (Kirchherr et al., 2017).

In addition, new findings in SBO knowledge have witnessed the SBO capacity in reducing the ammonia content in the anaerobic digestate of municipal solid waste (MSW) (Francavilla et al., 2017) if added in small amounts (0.05-2 % w/w) to the organic fraction of the fermentation slurry. This property is expected to be validated on an industrial scale in view of the EU supported Lifecab project (LIFE16 ENV/IT/000179), which involves the production of compost and the subsequent hydrolytic extraction of SBO, together with the analytical characterization of all the investigated biological streams.

This work addresses the collection of analytical data in order to monitor the seasonal and geographical variability of the compost. This activity results preparatory to the following phases of the European research project LIFECAB since the properties of the compost significantly affect not only the yield of the SBO extraction project but also the quality of SBO. After the selection of the parameters to be investigated, the analytical methods have been carefully discussed and designed. More specifically, the plants in charge of producing compost from feedstocks locally available were: the Italian ACEA Pinerolese Industriale (ACEA), the Greek Organohumik Thrakis (OT) and the Cypriot Sewerage Board of Limassol (SBLA). Analyses have been performed on the starting materials (i.e. green residue and digestate) and on the stable compost, highlighting the temporal evolution by monitoring physical and chemical parameters.

This work is divided in three main parts:

- collection of the materials involved in the analyses, taking into account the different materials used for compost production;
- description of the methodology employed for sampling and analytical measurements;
- analysis of the results, drawing conclusions through a statistical approach.

## 2. Materials and methods

### *2.1. Compost production*

ACEA, SBLA and OT produce compost from different raw materials: ACEA utilizes gardening residue (GR) and digestate (D), while both OT and SBLA utilizes only GR. Regarding OT, a mixture of mixture of olive mill solid wastes, dried municipal wastes, leaves, saw dust, and wood chips is employed, while SBLA uses a mixture of leaves, pruning, grass, soil and saw dust.

### 2.2. Sampling and analytical measurements

The selected compost sampling approach was the composite sampling (ANPA, 2001). Therefore, a composite sample constitutes a single sample for laboratory analysis composed of sub-samples uniformly distributed throughout the entire volume that, after mixing, accurately represents an average or median value of the property for a batch or general mass. For the specific case, the compost sampling was fixed once per week during the first month interested by an intense oxidation phase and once per month during the following two months of the curing phase.

After the sampling procedure, all samples were stored in suitable packages and placed at -20 °C until the day of analysis. Before the analyses, all the samples were dried and homogenized using a laboratory blender. Analyses included the assessment of pH, salinity, moisture, volatile solids (VS) and total carbon and nitrogen. Compost sampling and analyses were carried out according to ANPA (2001), DIVAPRA (1992), APHA (1998).

Data collected for this work regard four seasons and three European countries, and triplicate analyses for all samples were conducted for allowing application of statistical analysis and assessment of results' significance. For each parameter, the significance of the differences between the average values has been determined by one-way ANOVA analysis and Tuckey test. In conclusion, four experimental campaigns for raw materials and compost analyses were simultaneously conducted at ACEA, OT and SBLA site in September 2017, November 2017, February 2018 and April 2018.

## 3. Results and discussion

### 3.1. Compost evolution during the composting process

For each composting plants, we have monitored the evolution of compost during the composting process and Table 1 summaries the properties of starting materials and compost during the first season started in September 2017 for ACEA site.

**Table 1.** Properties (mean±SD) of the composting material during the first season started on 04/09/2017 at ACEA site. Different letter, within the columns, indicates that the values are significantly different ($P < 0.01$)

| *Time, weeks* | *Material* | *pH* | *Salinity, meq/100g* | *VS, % TS* | *C, % TS* | *N, % TS* | *C/N* |
|---|---|---|---|---|---|---|---|
| 0 | GR | 7.5±0.15a | 18.2±0.84a | 72.4±1.43a | 39.3±1.86a | 1.9±0.10a | 21.1±1.23a |
| 0 | D | 8.2±0.05b | 73.7±6.95b | 57.6±1.31b | 33.1±3.19b | 3.2±0.14b | 10.1±0.52b |
| 1 | compost | 8.1±0.03b | 39.2±5.36a | 62.0±0.10c | 31.6±2.41bc | 2.4±0.08c | 12.9±0.55c |
| 2 | compost | 8.3±0.07bc | 32.4±2.75a | 56.4±2.37b | 27.6±1.36c | 2.2±0.07ac | 12.6±0.80c |
| 3 | compost | 8.6±0.06c | 37.4±17.97a | 56.5±0.48b | 28.9±0.72bc | 2.1±0.11ac | 13.1±0.42c |
| 4 | compost | 8.4±0.04bc | 22.9±3.73a | 53.7±0.74b | 27.7±1.71c | 2.3±0.18c | 11.7±0.20b |
| 8 | compost | 8.4±0.14bc | 36.6±11.59a | 54.6±0.56b | 30.0±0.72bc | 2.3±0.12c | 12.7±0.87c |
| 12 | compost | 8.2±0.08b | 20.9±3.03a | 53.8±0.14b | 28.9±0.13c | 3.0±0.08b | 9.3±0.26bc |

The main characteristics of the composts do not point out relevant variations during composting. The most significant differences are between the two starting materials (GR and D): the digestate exhibits higher pH, salinity, and N content than the gardening residues, which are richer in organic carbon and volatile substances. These results are in agreement with the nature of the materials.

### *3.2. Compost seasonal variation*

The analyses carried out in September 2017 were repeated in order to assess the seasonal variability for each composting plants. The comparison between the composts obtained during the three completed seasons pointed out some significant differences as far as the carbon and nitrogen content were concerned. For example, for ACEA premises (Fig. 1), the observed trend is an increase of C and a decrease of N from season 1 to season 3, reflecting an increase of the C/N ratio. No significant differences have been noticed for pH, salinity and VS.

The data of season 4 (to be completed) will be useful for confirming such trend.

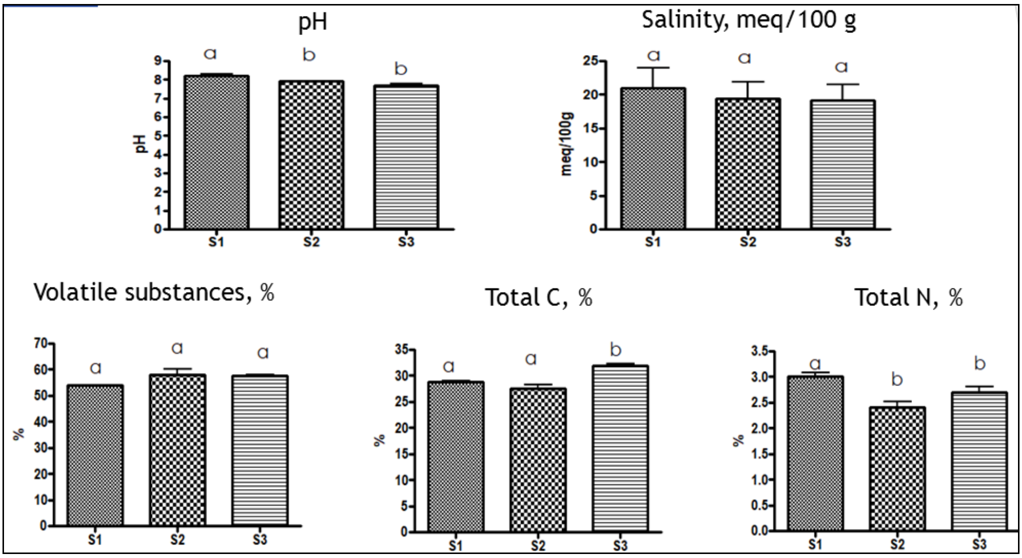


**Fig. 1.** Comparison of the stable compost properties (at the end of the composting process) for samples deriving from ACAE site. The parameters investigated were pH, salinity, volatile substances, total carbon and total nitrogen. S1: first season (started in September 2017), S2: second season (started in November 2017), S3: third season (started in February 2018)

### *3.3. Effect of the sampling time on the properties of the starting materials*

The raw materials used as a feedstock for compost production have been analysed for each composting site at the beginning of the process. The most significant differences were noticed at ACEA site where both digestate and green residue were used for the compost production. In this case, the seasonal variability affects the content of both total nitrogen and total carbon. Furthermore, as far as the ACEA GR is concerned, the variations in nitrogen content could be due to the differences of protein content of the lignocellulosic material and to the maturation of the pile, while the different carbon content is related to the partial maturation of the green wastes during the storage which leads to a loss of carbon as $CO_2$. Similarly, the digestate strongly depends on seasonal variability as well, because of the seasonal variability of the food wastes used for feeding the digestor.

### *3.4. Compost geographical variation (Italy. Greece and Cyprus)*

Finally, compost samples collected simultaneously from Italy, Greece and Cyprus were compared for evaluating the geographical variability (Fig. 2). Significant differences in carbon and nitrogen content were noticed comparing the compost produced at ACEA site with the ones obtained at OT and SBLA premises. This behavior is mainly related to the fact that ACEA utilizes both digestate and green residue for compost mixture, whereas OT and SBLA obtains their compost only from green residue (please, see Section 5.1 for the differences between D and GR).

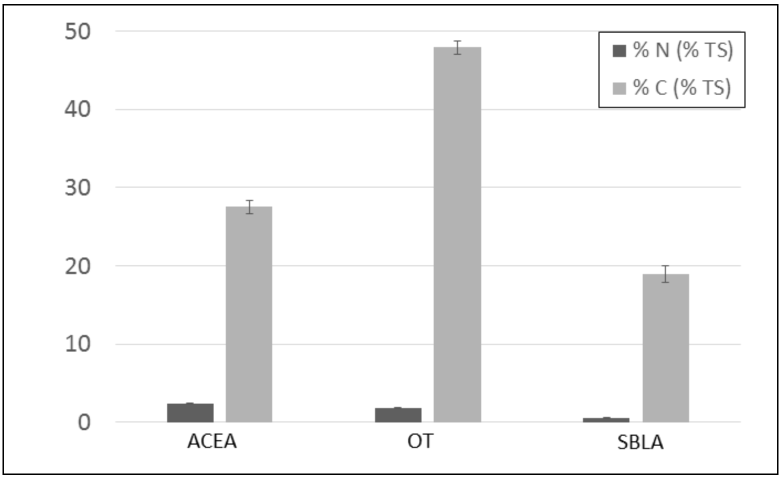


**Fig. 2.** Comparison of the stable compost (compost at the end of the process) obtained at ACEA, OT and SBLA sites. More specifically, the figure takes into account the analyses of total carbon and total nitrogen for season 2 (started in November 2017)

## 4. Concluding remarks

The properties of the compost vary according to the season and to the local environmental conditions. Therefore, in this extensive study different compost samples collected throughout four seasons and in three European countries have been analyzed, in order to identify the best period of the year as well as location to produce compost for the subsequent SBO extraction. In the future framework, after the extraction of SBO compounds from compost, correlations will be provided for drawing relationships between hydrolysis process parameters, nature of the starting materials and SBO yield and quality.

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