Urban bio-waste valorization – resource evaluation and characterization for energy recovery by anaerobic digestion

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DEEP Laboratory, Université de Lyon, INSA Lyon
1- Introduction
   - Challenge of urban biowaste management
   - Technical option selected in the project UrbanBioM: methane conversion

2- Urban biowaste identification
   - Targeted territory
   - Selection of the major stream

3- Urban biowaste characterization
   - Sampling
   - Analytical procedure
   - Main results

4- Conclusions and future trends of the project
Urban biowaste include of organic waste produced in urban areas, such as garden and park waste, food and kitchen waste from households, restaurants, caterers and retail premises, and comparable waste from food processing plants;

Yet, biowaste production is still growing in most cities, following the growth of population;

In agreement with the European Directives, separated source collection of bio-waste and the implementation of a public service for resources recovery from them will be made mandatory in 2025;

In many urban areas however, the efficiency of source separated collection often remains relatively poor, in particular for urban biowaste;

The environmental quality of biowaste is strongly affected by the presence of several undesirable fractions, including in some cases hazardous domestic waste, making it difficult to recycle organic matter for agricultural purposes.
The objective of the first step of the multi-partners project URBANBIOM is to identity and characterize biowaste streams produced in an urban territory, with regards to their potential use as feedstock for anaerobic digestion.
The UrbanBioM project will provide decision support for solutions and, ultimately, projects for new recovery facilities to be favored. These elements will also feed into the reflections initiated by Lyon Metropole on the implementation of biowaste selective sorting by 2025, and the treatment methods to be considered in the case of the capture of part of the biowaste generated in this urban area.
2- Urban biowaste identification

Targeted territory

Actual issues
On the territory to manage waste:

- Anaerobic digestion
- Gasification
- Composting
- Incineration

Potential mobilizing quantity:

Food waste from restaurants

- FFOM; 50.06%
- DV; 18.91%
- Comerces; 1.67%
- Marchés; 1.67%
- Distribution; 7.23%
- IAA; 3.34%
- Distribution en régie; 5.23%
- Distribution en sous contrat; 1.67%
- Hauss aménagements; 0.78%
- Restauration commerciale; 1.67%
- Restauration scolaire; 2.78%
- Restauration santé; 2.22%
- Restauration sous contrat; 1.67%
- Restauration en régie; 5.23%
- Comerces; 4.45%
- Comerces; 4.45%
- Comerces; 4.45%
Selection of the major stream (to characterize) was based on several criteria:

- **Potential mobilizing quantity**: take into account the quantitative issues of valorization of the biowaste. In fact, the larger the biowaste, the greater interest of valuation.

- **Availability (dispersion, accessibility, adhesion)**: take into account the issues related to the effective implementation of the sector and more particularly the collection;

- **Territorial orientation and Political Priority**: take into account the political and societal issues specific to the territory: political decision, local dynamics, ongoing projects.

- **Local context of valuation**: take into account the existing sectors established locally (maturity of the processing and valorization, development, implantation projects), and thus preferentially target the flows currently little or not valued.
3- Urban biowaste characterization

Selection of biowaste for a full characterization

- **Food waste from households (HBW)**
  
  2 scenarios of collect: from 9,000 t/year to 45,000 t/year

- **Food waste from restaurants (RBW)**
  
  6,400 t/year to 8,200 t/year

- **Food wastes from Supermarkets (SMBW)**
  
  3,000 t/year to 6,500 t/year

- **Urban Green Waste (GBW) from domestic, municipal and private activities**
  
  15,000 t/year to 16,000 t/year
Multiphasic analytical procedure

The **procedure** was based on water extraction of the raw sample, which enabled the measurement of the contributions of **water-soluble** and **particulate phases** of biomass dedicated to anaerobic digestion.

**Leaching procedure:** 10:1 water/TS ratio during 2 h under constant flip-flop rotation (10 rpm)

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**Analysis**

**Raw sample**
- TS; VS; BMP
- Elementary analysis (CHNOS)
- OOM + inert materials, (Plastics, gravels, glass)
- Granulometry
- Water retention capacity

**Particulate**
- TS; VS; COD; TKN;
- Organic fibers (Van't Soest extraction)
- TG-DSC

**Water soluble**
- TS; VS;
- BMP
- pH
- COD; WSC; VFA
- TKN; NH₃-N
Global composition:

- Oxydisable organic fraction
- Minerals
- Plastics

Urban Green Biowaste (GBW)

- Inert content nearly 30% for green waste;
- Around 3% of inert mat. in biowaste from households and biowaste from supermarket biowaste, and close to 5%TS in biowaste from restauration;
- Presence of close to 40%TS synthetic plastic-type organic materials from packaging

Food waste from Restaurants (RBW)

Food waste from Households (HBW)

SuperMarket food Biowaste (SMBW)
No significant differences in methane bioconversion rates were observed. Except for green biowaste, 95% of the BMP were expressed in less than 20 days of incubation. This results suggested that food waste from restauration, supermarket and households have fairly the same potential of bioconversion in AD.

The overall BMP of food waste from restauration (RBW), households (HBW) and supermarket (SMBW) ranged between 250 and 470 NLCH4.g-1 . HBW showed the lowest BMP value, probably in relation to the characteristics of the organic matter contained in this biowaste.
3- Urban biowaste characterization

Liquid/Solid distribution of COD and PBM *after leaching test*

The green biowaste GBW differed here from the other three samples by a very high DCOL / DCOS ratio of 26 whereas the other samples ranged between 2.9 to 3.3. GBW also showed lower overall BMP, and a very low BMP of the solid fraction, between 40 and 71 NL$_{CH_4}$ g$^{-1}$, ie 5 to 10 times lower than observed with the other biowaste.

However, the distribution of BMP, compared to COD was relatively similar in the 4 samples.
The Green Waste does not have the favorable characteristics for methane bioconversion: soluble fraction that can not be easily mobilized in contact with water. PBM of the particle fraction is much too low to justify its selection for anaerobic digestion. Its high content of inert and mineral materials (nearly one third of the total content) leads to consider it as being unsuitable for recovery by AD.

Despite a lower bioconversion rate, biowaste obtained from a "source" selective collection from households (HBW) remains interesting, since part of the PBM is easily extractable in contact with water - leaching (31%, with a simple contact L / S ratio 10, 2h with gentle stirring), which suggests its selection for AD and a good potentiality of pretreatment for liquid to solid separation.

With its highest BMP potential, biowaste collected from restaurant (RBW) is well suited to recovery methane by anaerobic digestion. The extraction rate of the BMP in contact with water is of the order of 21% (and 23% for COD), requiring the need to pretreat this biowaste in order to extract the PBM predominantly present in the solid fraction.

The biowaste collected from supermarket (SMBW) differs from the other three biowaste with the presence of nearly 40% of plastics from packaging. Despite this, its total BMP is between 450 NLCH\textsubscript{4}.kg\textsuperscript{-1}, after packaging collection.
4- Conclusion and future technical trends

Pretreatments selected

The preparation conditions of the four biowaste will be the subject of the next steps of the project, the objective of which is to determine their suitability for trituration pretreatment (mechanical preparation) and liquid / solid separation in order to produce a solid grade dedicated to thermochemical treatment and a liquid grade, pulp consisting mainly of biodegradable organic material dedicated to anaerobic digestion, wet process.

- **Filtrer press**
- **Spin-dryer**
- **Extrusion**

Lab-scale under work since March, and up-scaling in September 2019 for demonstration on:

- AD on “liquid grade”
- Gasification on “Solid”
- + syngas methanation
Thank you for your attention!

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2- Urban biowaste identification
Quantitative production and selection of the major stream

Tableau 66 : Proportions des différents gisements dans le cas d'une collecte généralisée de la FFOM

<table>
<thead>
<tr>
<th>Flux de biodéchets</th>
<th>Part estimation basse (%)</th>
<th>Part estimation haute (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FFOM généralisée</td>
<td>49,50%</td>
<td>50,06%</td>
</tr>
<tr>
<td>Restauration Commerciale</td>
<td>0,83%</td>
<td>1,67%</td>
</tr>
<tr>
<td>Restauration Scolaire</td>
<td>0,83%</td>
<td>2,78%</td>
</tr>
<tr>
<td>Restauration santé</td>
<td>2,31%</td>
<td>2,22%</td>
</tr>
<tr>
<td>Restauration sous contrat</td>
<td>0,99%</td>
<td>1,67%</td>
</tr>
<tr>
<td>Restauration en régie</td>
<td>7,43%</td>
<td>5,23%</td>
</tr>
<tr>
<td>HAU</td>
<td>0,99%</td>
<td>0,78%</td>
</tr>
<tr>
<td>IAA</td>
<td>1,98%</td>
<td>3,34%</td>
</tr>
<tr>
<td>Distribution</td>
<td>4,95%</td>
<td>7,23%</td>
</tr>
<tr>
<td>Petits Commerces</td>
<td>1,65%</td>
<td>4,45%</td>
</tr>
<tr>
<td>Marchés</td>
<td>2,15%</td>
<td>1,67%</td>
</tr>
<tr>
<td>DV</td>
<td>26,40%</td>
<td>18,91%</td>
</tr>
</tbody>
</table>
2- Urban biowaste identification

Quantitative production and selection of the major stream

- DV
- DR
- FFOM
- DGM

Conditionnement
Prétraitements / Séparation / Séchage

Grade 1
« Bio-CSR »

Gazéification/ Méthanation

Produits secs, ligneux, peu biodégradables

Grade 2
« Biodégradable »

Gaz de biomasse

Méthanisation/ Concentration

Injection de Biométhane

Limite du projet
Conditionnement pour valorisation thermochimique

Digestat

Valorisation matière