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Statistical analysis to correlate bio-physical and chemical characteristics of organic wastes and digestates to their anaerobic biodegradability

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Dry anaerobic digestion development of different kinds of residual organic wastes

- Biowaste (BW)

- Collection from domestic sources of green and food waste

- Collection from agro-industries (food processing waste), agriculture (green waste) and other factories (papers, cardboards,…)

- Residual Municipal Solid waste (RMSW)

- Residues from MBT of MSW,

- Segregated fraction from MBT of MSW






High variability of the feedstocks might be problematic to control the AD process

Determining bioreactivity on solid waste for anaerobic digestion, for what?

- **A better knowledge of the Substrates (input)**
  - **Estimating of the biomethane potential ;**
  - **Controlling the AD process (feedstock pretreatments, co-digestion,…) ;**
  - **Modeling the AD process and having a better understanding of the biological activities.**

- **A better knowledge of the digestates (output)**
  - **Estimating biostability and the needs of post treatments in accordance with the end of life scenario;**
  - **Determining the solid mass balance of biodegradable fractions and conversion rate.**

Objective

Comparing selected methods to assess biodegradability or biostability of biowaste and refuse from MSW in the way to:

- Determine the relationships between bioreactivity and OM content and its biochemical properties.

- Select the relevant tests to evaluate the bioreactivity of a large profile of solid samples (substrates or digestates)

Methods

Solid waste and digestate collection

Data set obtained by analyzing samples collected from full-scale HS AD plants : 4 substrates and their respective digestates.

AD plant	Waste	T°C	Biogas production (Nm^3/t inlet)
Calais (France)	Food waste Green waste Grease Mechanical crushing	55	winter : 150 - 160 summer : 100 - 120
Varennes-Jarcy France	RMSW Rotating Composting Mechanical sorting And crushing (< 12mm)	37	110 - 120
Ecoparc II Barcelona (Spain)	RMSW + Green waste Manual and mechanical sorting And crushing (< 60mm)	37	114

Methods

Analyses

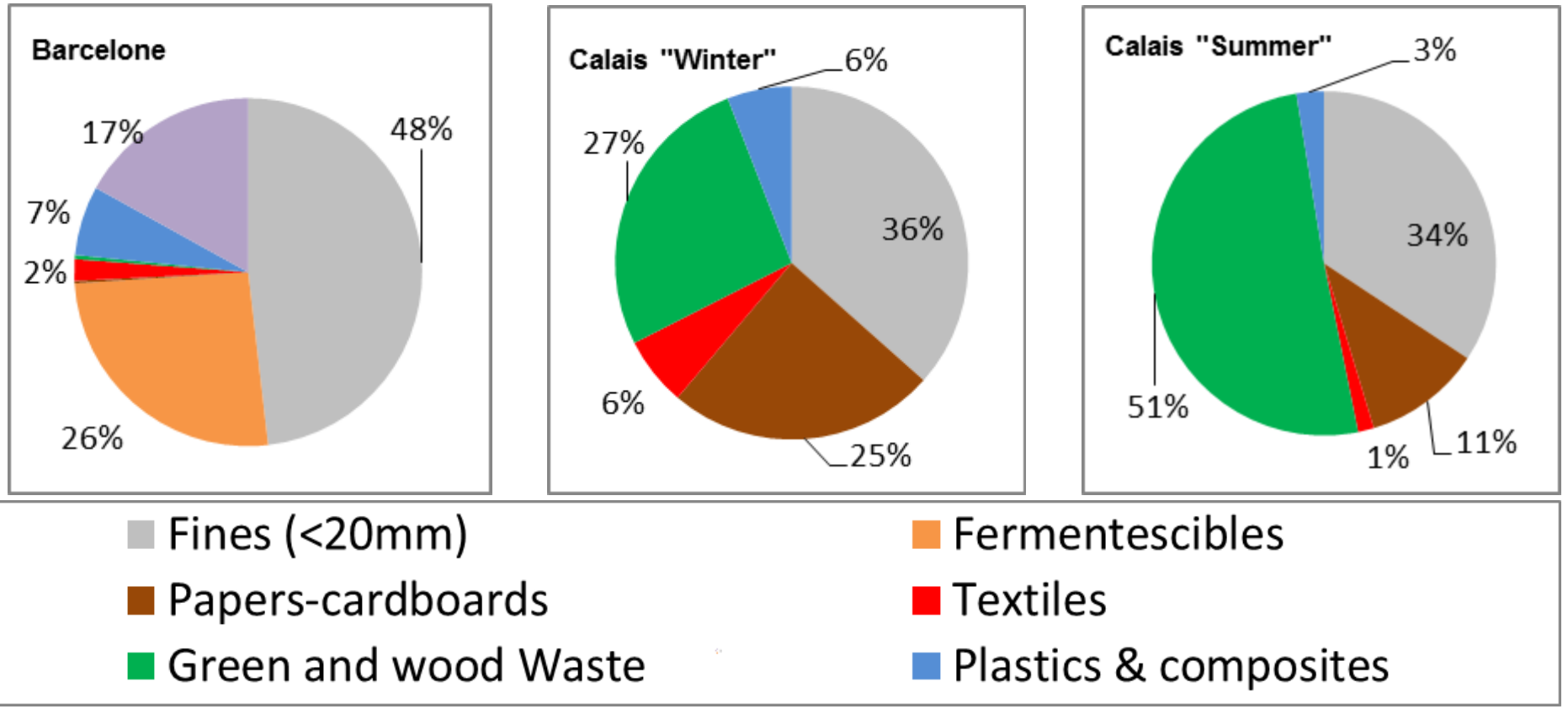
OM quantification (Level #1)	- VS (ignition loss) - TOC (combustion method) - COD on solid samples (dichromate oxidation) - Dissolvable Organic carbon in water – DOC (leaching test L/S = 10, 3h)
Biochemical analysis (Level #2)	- Lipids, and proteins - Humic substances extraction (alkaline & acid extraction) - Carbohydrates (van Soest's sequential extraction procedure)
Bioreactivity measurements (Level #3)	- BOD_{28} measurement on suspended solid samples - Biomethane potential (BMP_{60}) on suspended solid samples

BOD

BMP

Results

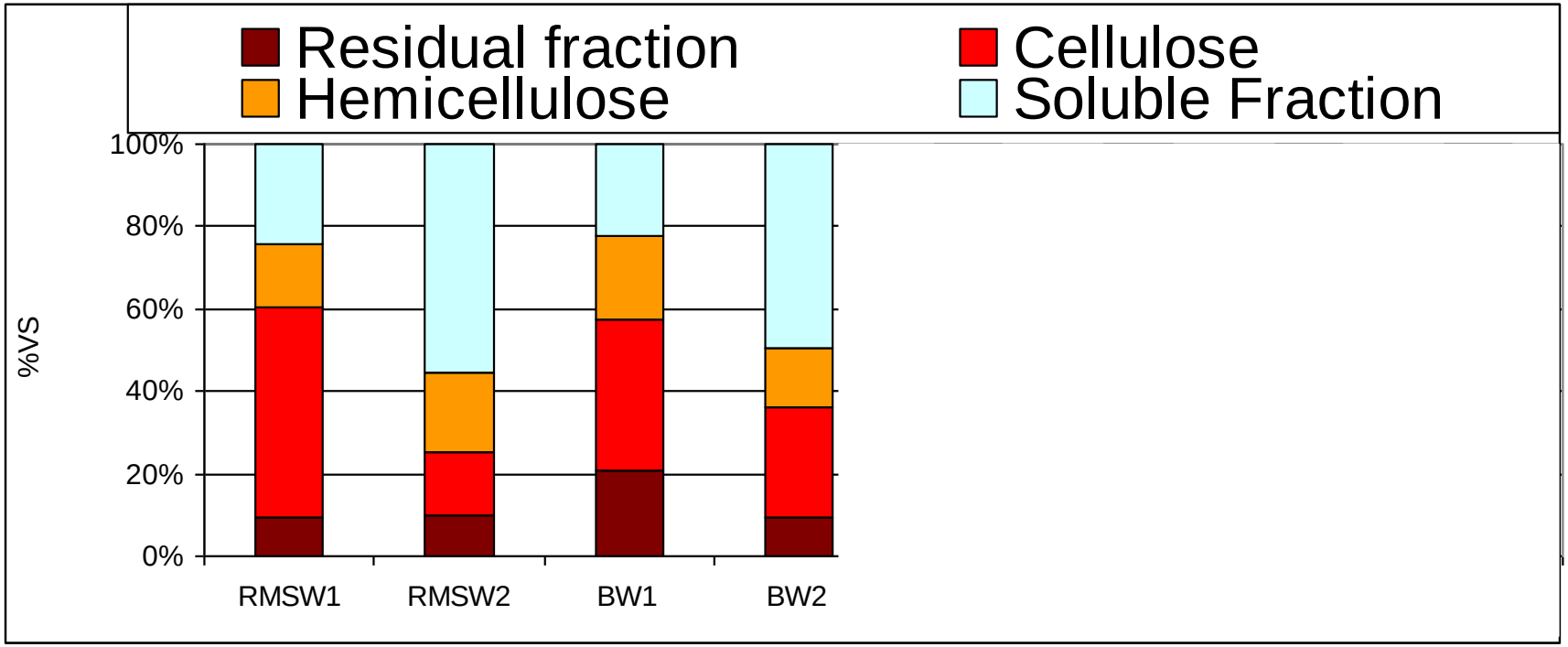
Solid waste composition (insp. from MODECOM meth.)



- **High variability of substrates from one site to another**
- **Seasonal variability of biowaste**

Results

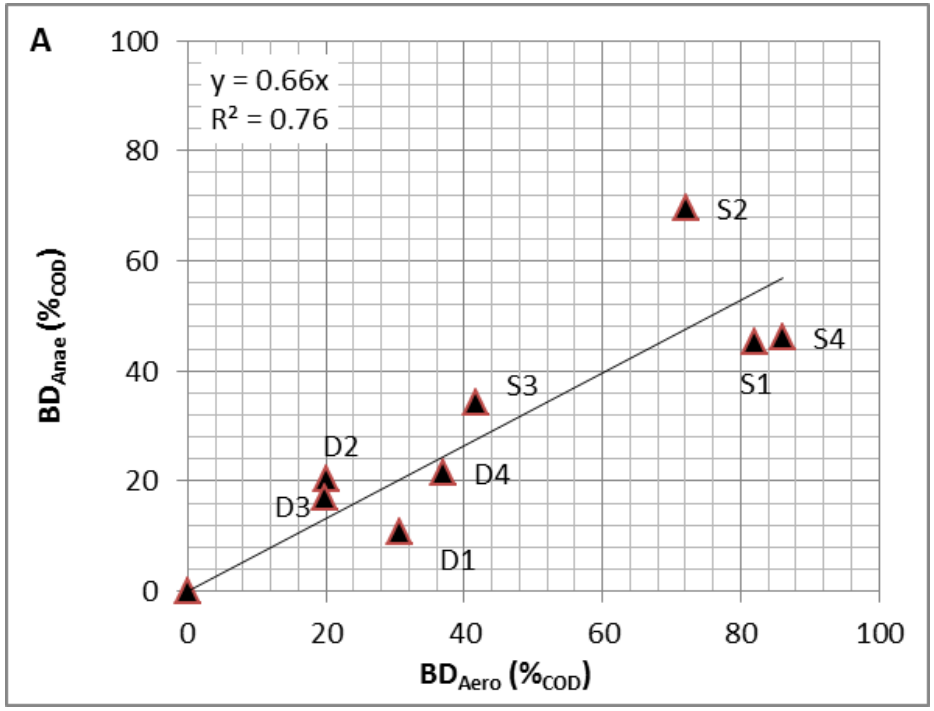
Biochemical analysis

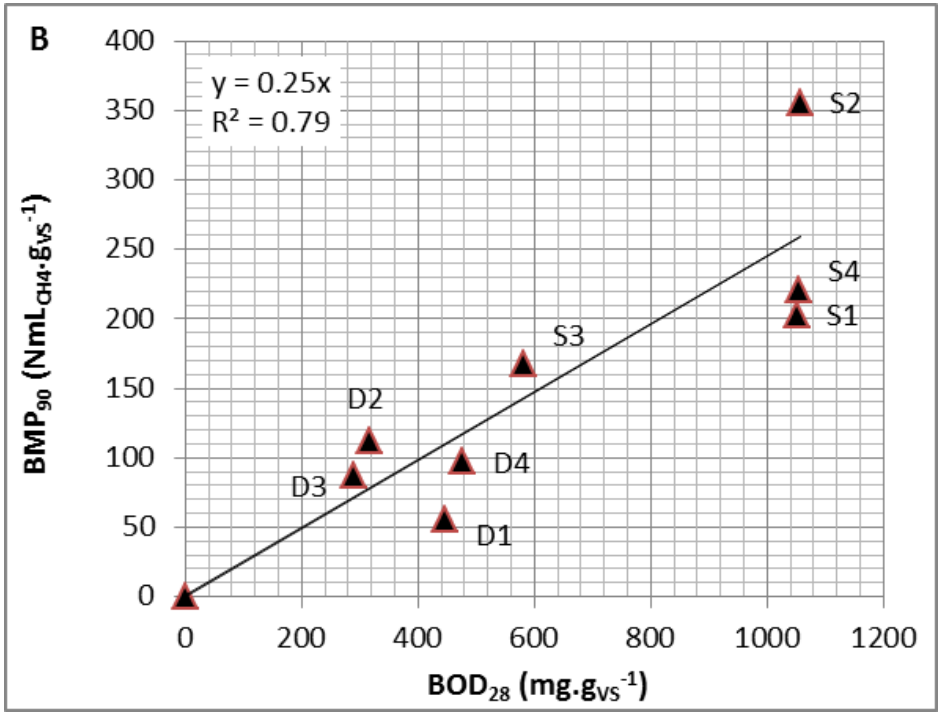


- **High variability between feedstocks (source, season, and pretreatment effect),**
- **Higher residual and soluble fractions in digestates (lower cellulose and hemicellulose).**

Results

Correlation between BD_{Ana} / BD_{Aero} and BMP_{90}/BOD_{28}

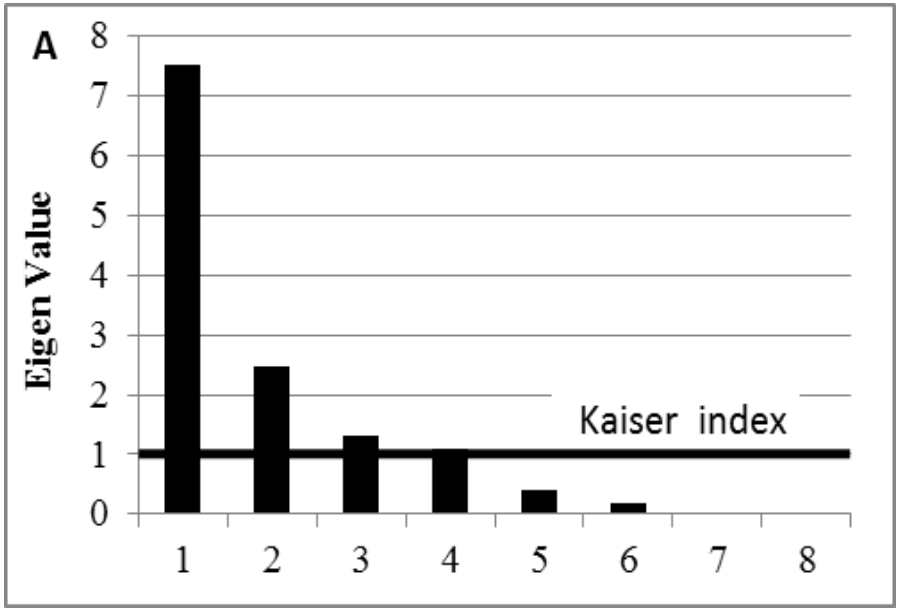


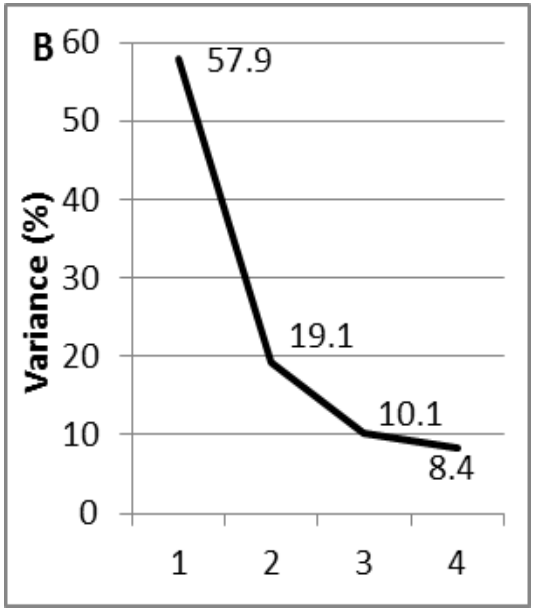


- **OM less biodegradable in anaerobic conditions,,**
- **Significant correlation between BMP and BOD tests,**

Structural effect of organic fraction, reducing OM bioaccessibility?

Principal Component Analysis (PCA)



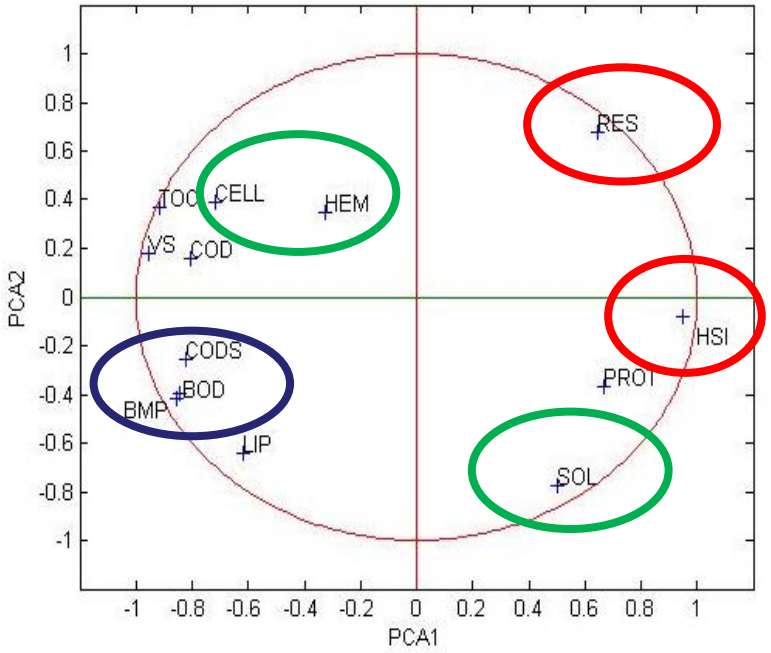


Principal Component	(%)
PC1	57.9
PC2	77.0
PC3	87.1
PC4	95.5
PC5	98.6
PC6	99.8
PC7	100.0
PC8	100.0

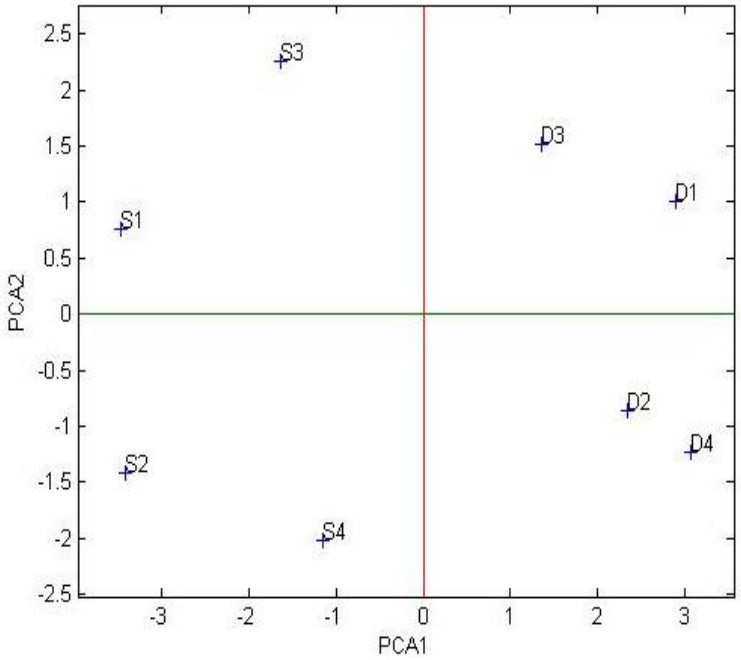
- **The first two PC, represented ≈ 80% of the variability of the data**

Principal Component Analysis (PCA) - factorial plan

A : PC1xPC2 – Variables



B : PC1xPC2 – Samples



- Relevant biochemical variable to estimate biostability : RES and HSI in opposition to BMP and BOD;
- Correlation between BOD, BMP and soluble COD ;
- **No clear correlation between BMP and soluble, hemicellulose and cellulose;**
- **Significant distinction between substrates and digestates, revealing that AD treatment affected biological and chemical characteristics of the waste**

First trends…

- **No surprise : impossible to distinguish biodegradable and non biodegradable OM with chemical analyses;**
- **Promising linear correlation between anaerobic bioreactivity and residual fraction "RES" from Van't Soest sequential extraction;**
- **Linear correlation between aerobic and anaerobic bioreactivity (confirmed on more samples),**

With limits …

- **Bioreactivity measurement test seems to be unavoidable!!**

Conclusion / work in progress

- **Running methodology on a larger range of solid waste samples including fresh and treated waste (from anaerobic and aerobic MBT plants);**
- **Developing other methods: thermogravimetric analysis, structural analyses (DRX, FTIR, …);**
- **Statistical analyses of the data like Partial Least Square Regression (PLS-R) under development to predict PBM from data sets)..**

efcharistó for attention!

Any questions?

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