COST FP0901 meeting „Current needs in biorefinery analytics“
WG 3: Process Residues

Requirements for characterization of biorefinery residues

Ina Körner[1], Ron Janzon[2], Helmut Adwiraah[1],
Jörn Heerenklage[1], Tim Sieker[3], Bodo Saake[2]

1) Hamburg University of Technology (TUHH)
Institute of Environmental Technology and Energy Economics (IUE)
Bioconversion & Emission Control Group

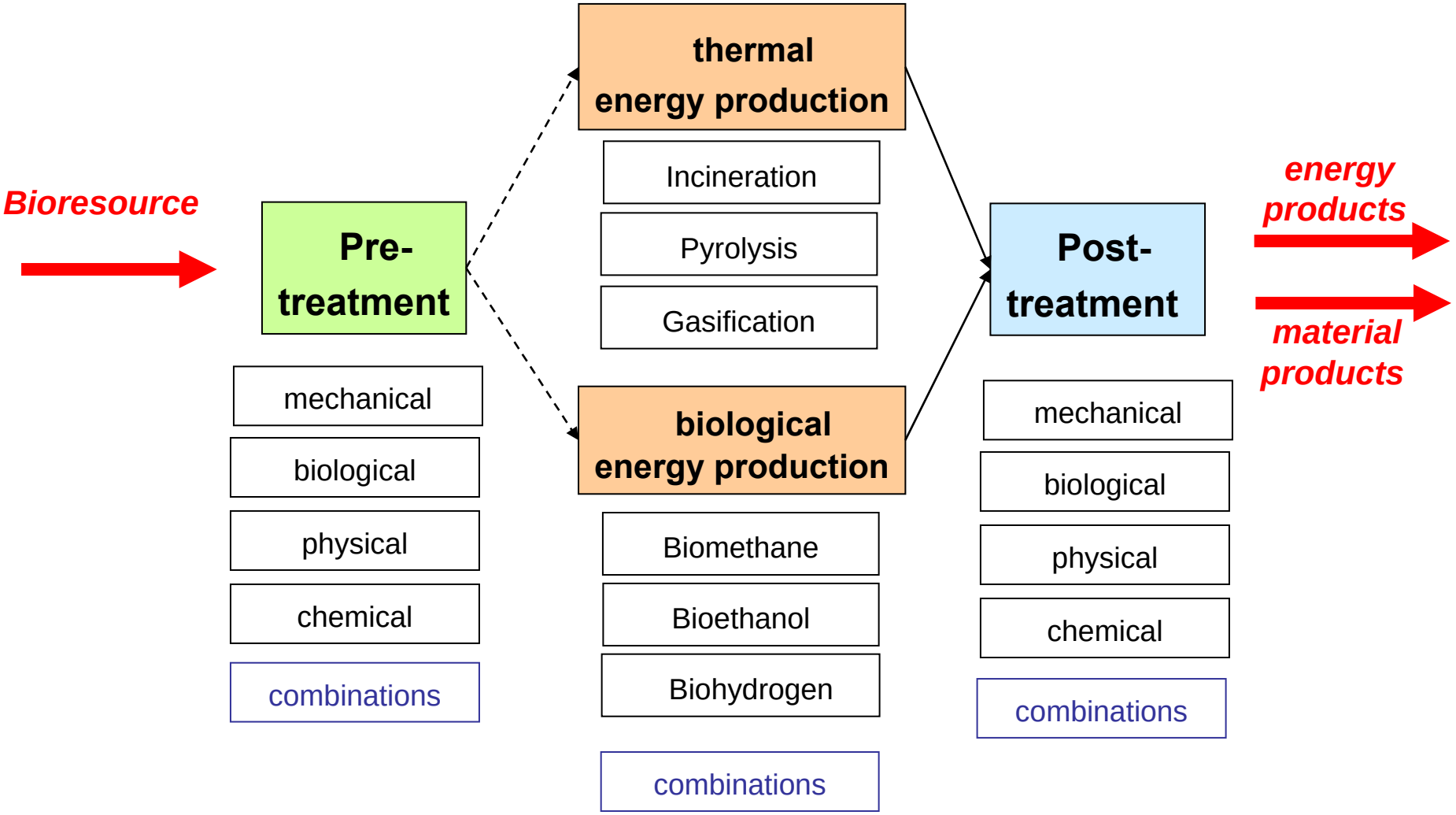
2) Johann Heinrich von Thünen-Institut – (vTI)
Institute of Wood Technology and Wood Biology

3) University of Kaiserslautern
Department of Mechanical and Process Engineering
Institute of Bioprocess Engineering

Overview

1. **Biorefineries**
2. **Goals of characterization**
3. **Characterization requirements & methods**
4. **Summary & conclusions**

Biorefineries: Principle setup



Substrates for biorefineries

1st Generation

Feeding beet, wheat, rye, maize (grain, whole plant, silage)

2nd Generation

Common forestry wood
Fast growing wood
Straw

Waste

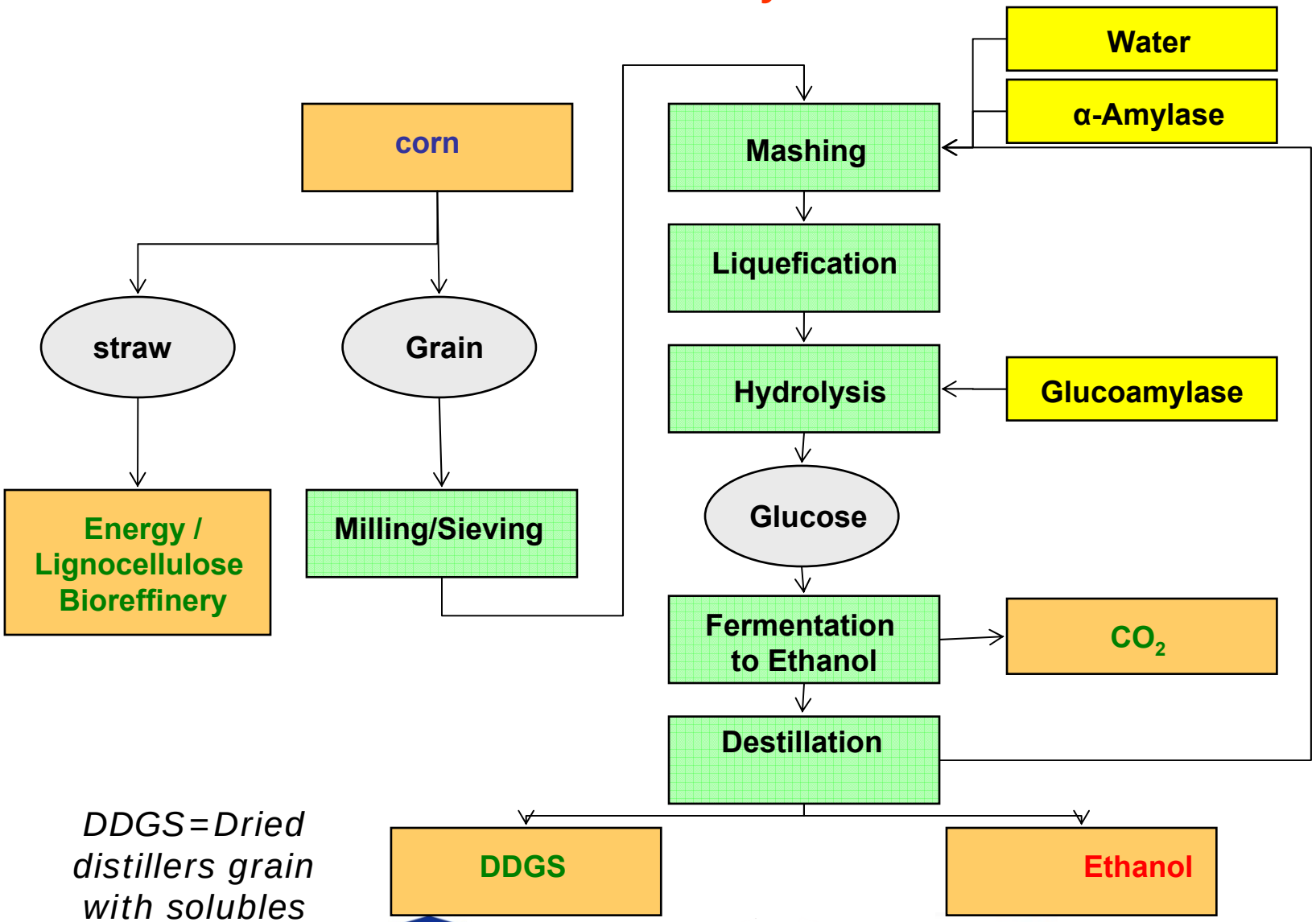
Mixed Municipal waste
Source separated organic waste
Agricultural waste
Green lignocellulosic waste






1st Generation Biorefineries:

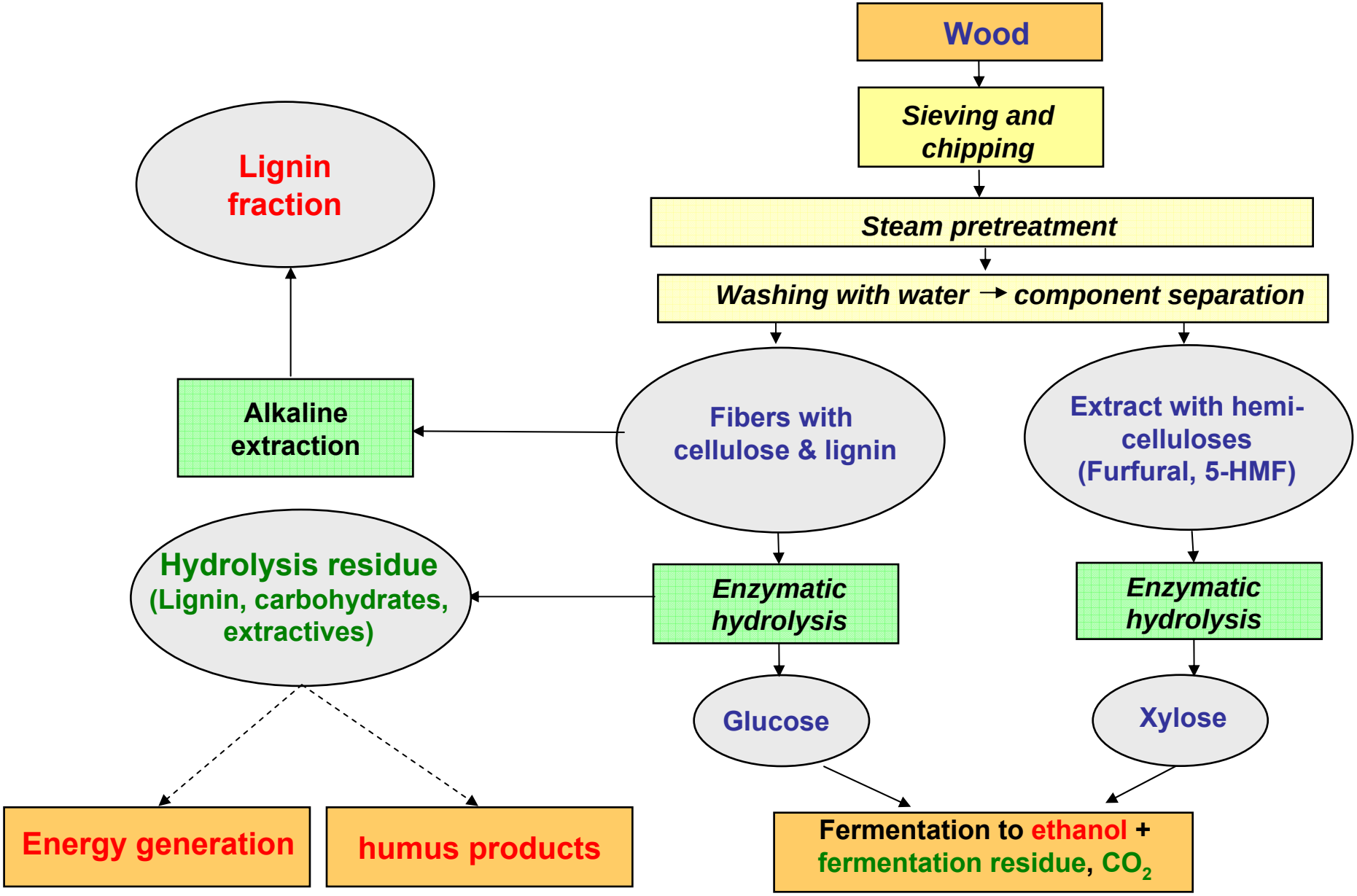
Wheat-to-Bioethanol-Biorefiniery



DDGS=Dried distillers grain with solubles

2st Generation Biorefineries:

Lignocellulose-to-Bioethanol-Biorefiniery



Waste Biorefineries

Biowaste-to-Biogas Biorefinery

Biobin-Waste

Anaerobic dry fermentation

Bioconversion processes into a methane-rich biogas

Biogas

Digestate = Residue

Emissions, Residues

Heat, Electricity

Natural gas substitute

e.g.

Liquide fertilizers

Tailor-made composts

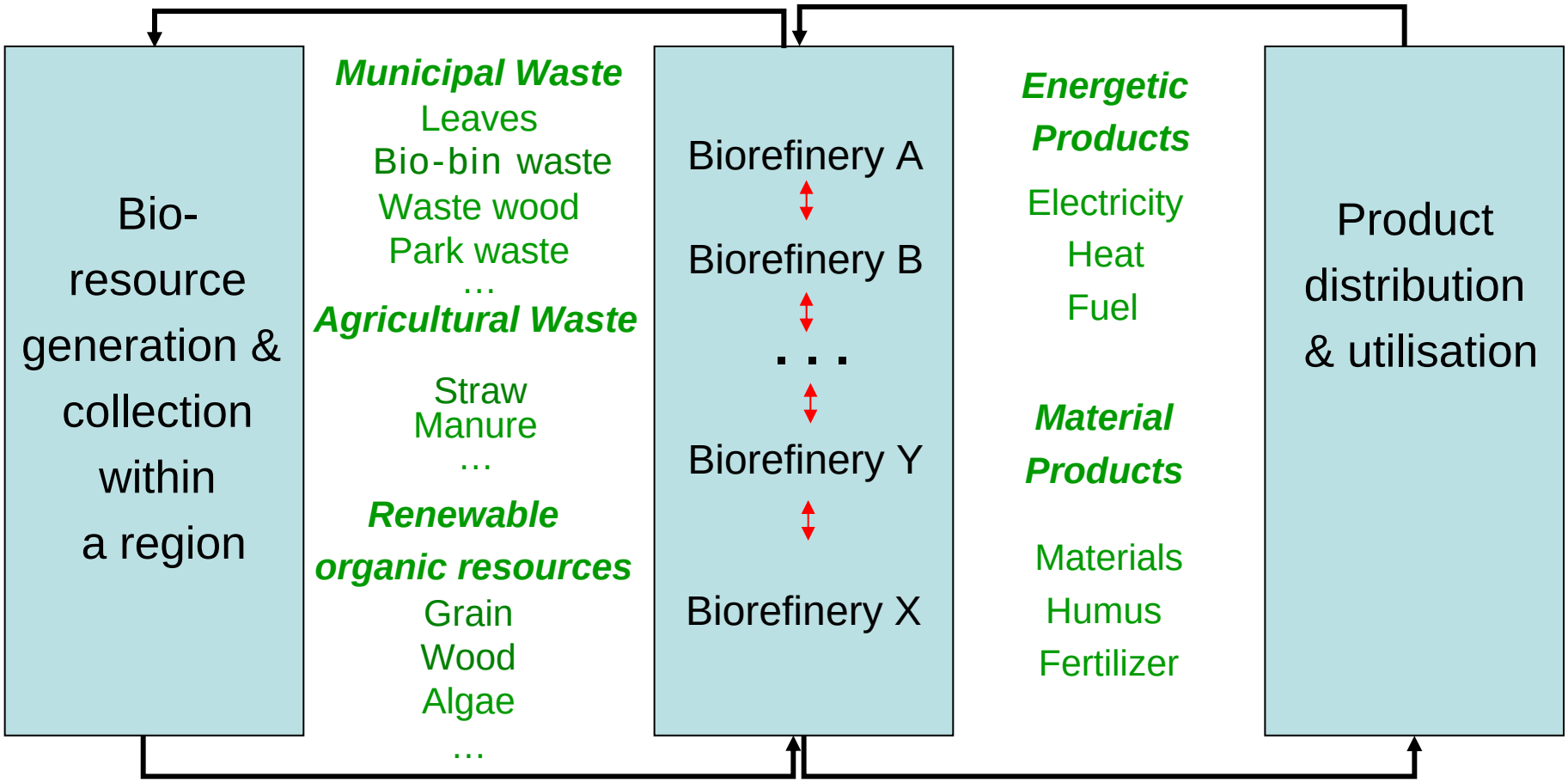
pellets

Solid mineral fertilizers

Emissions, Residues

Civilisation Biorefinery

Complex of biorefineries for utilization of regional bioresources



Characterization Goals

Process Design

- Develop process steps for transformation of solid, liquid, gaseous residues into products
- Design intermediate and final product storage systems and distribution systems

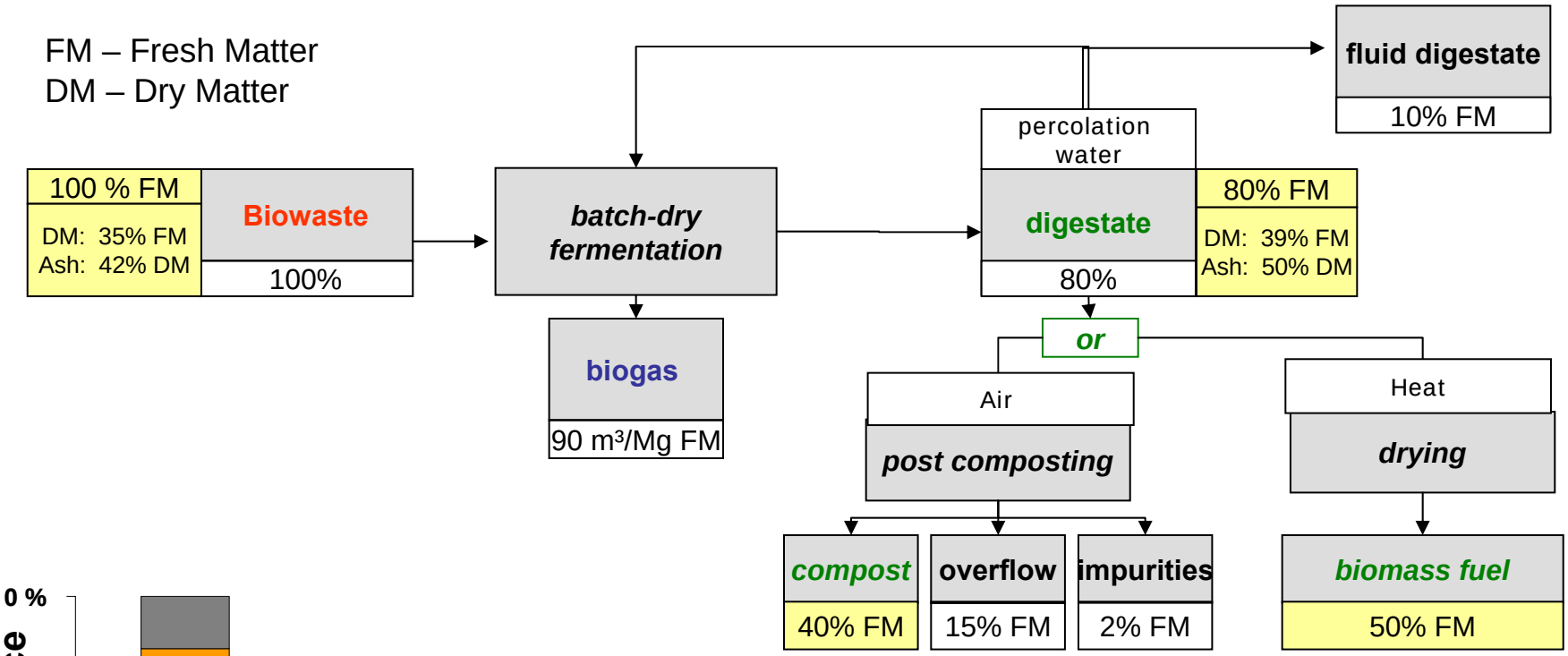
Process and Product Control

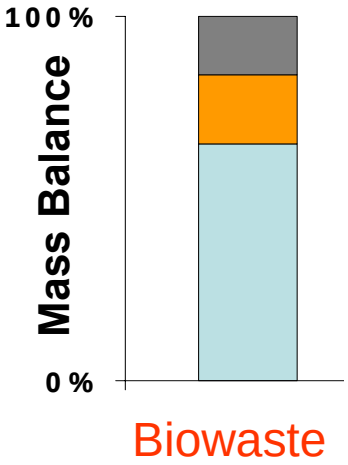
- Ensure stabile and efficient run of all technological steps
- Ensure suitable residue qualities for further transformation, utilization or disposal

Characterization requirements

Input-Output characteristics of anaerobic fermentation

FM – Fresh Matter
DM – Dry Matter



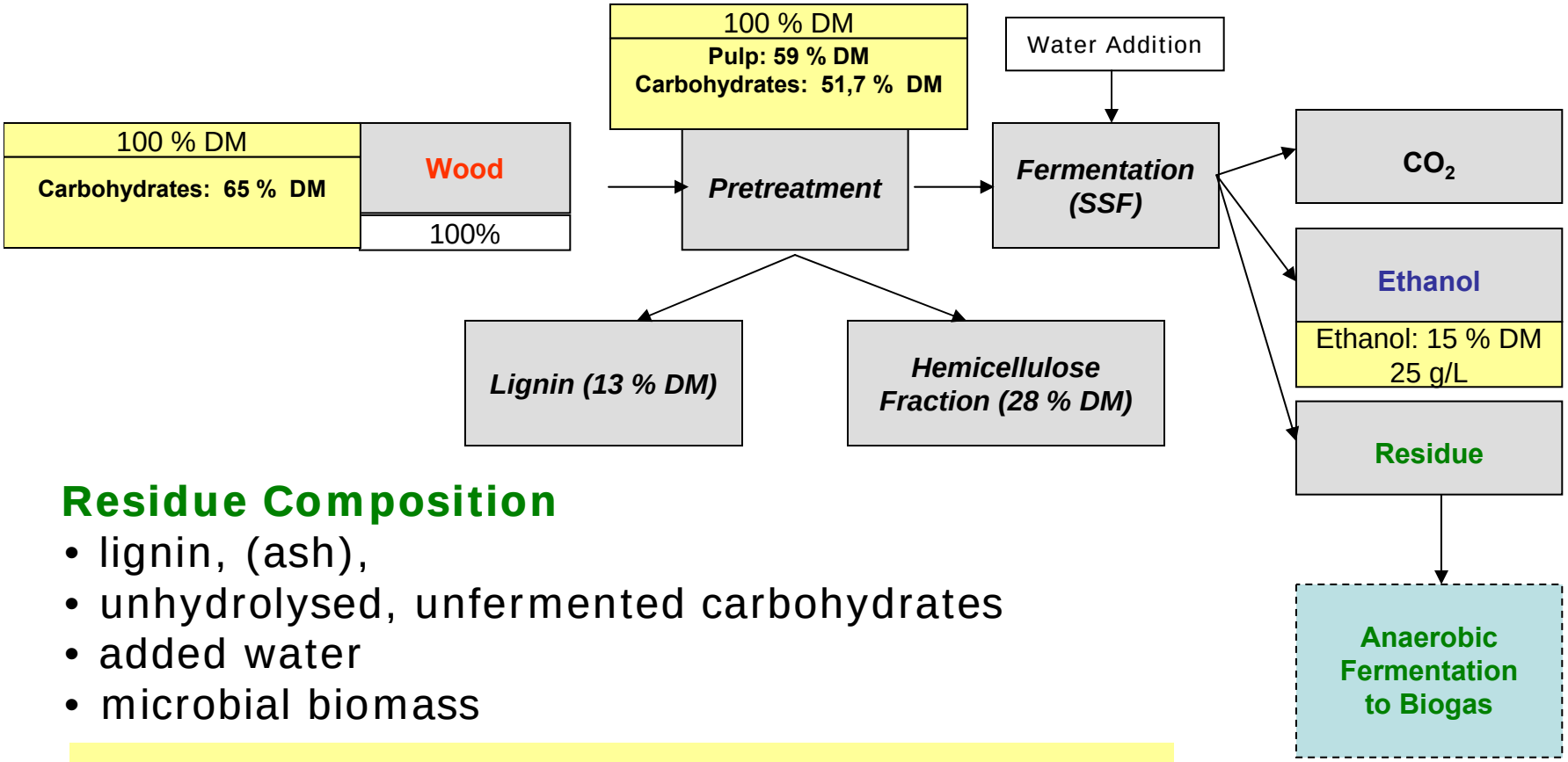


Ash
Organic
H_2O

are most important parameters

Characterization Requirements

Input-Output characteristics of Bioethanol-Process



Residue Composition

- lignin, (ash),
- unhydrolysed, unfermented carbohydrates
- added water
- microbial biomass

Water & organic content are most important parameters

SSF: Simultanious saccarification and Fermentation

Basic measurements

Methods for Products:

- Biogas (Volume; CH_4; CO_2)
- Ethanol

→ *Well established*

Methods for Residues:

- Water
- Ash / organics

Main Problems - Laboratory:

Inhomogenity → Sampling →
Sample Storage → Sample Preparation

Various Digestates

„Fist"-method suggested in composting guidelines

Material with optimal moisture content

Material too dry

Material too wet

Main Problems - Practice:

Easy → Quick → Cheap

BUT: Less exact

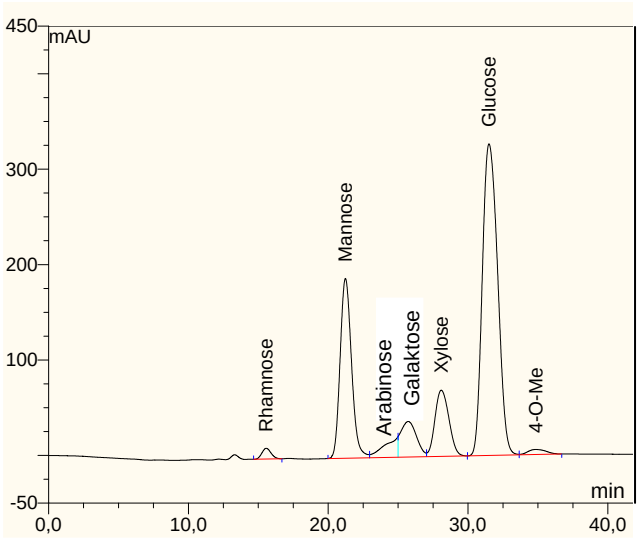
Special Measurements: Component Analytics

Carbohydrate & lignin determination used in wood science

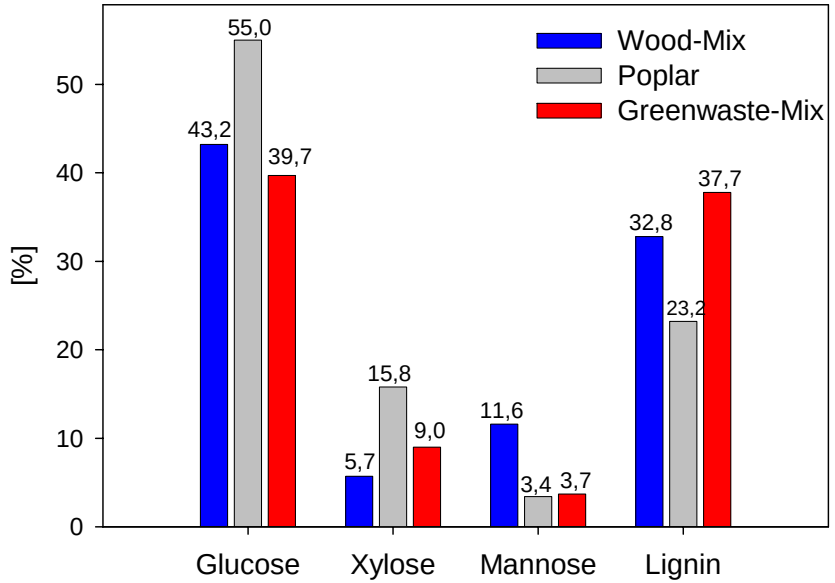
Sample is hydrolysed by a 2-step procedure with H_2SO_4

Wood monosaccharids are detected by HPLC

Hydrolysis residue (lignin) is determined gravimetrically



HPLC-Chromatogram of a wood-mix



Components in various samples

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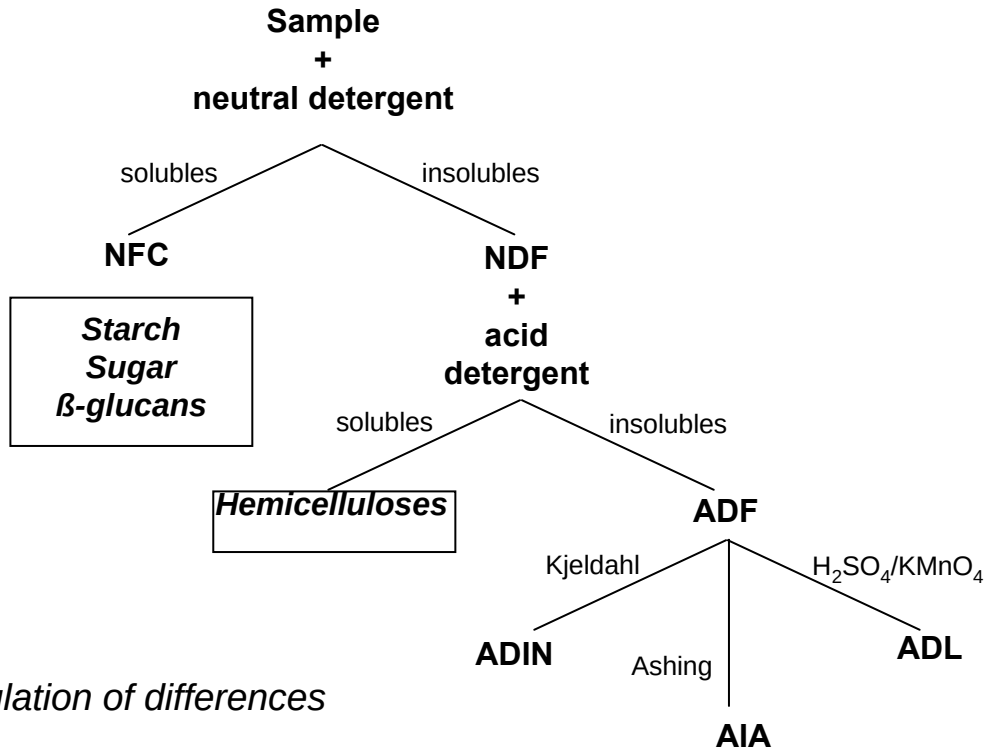
Special Measurements: Component Analytics

Van Soest analysis used in waste science

Separation of the two fraction: by neutral and an acid detergents:

- neutral detergent (Na-lauryl sulfate + **e**thylene**d**iamine**t**etraacetic **a**cid, pH =7.0)
- acid detergent (**c**etyl **t**rimethyl **a**mmonium **b**romide in 1 N H_2SO_4).



Calculation of differences

NDF: Neutral Detergent Fiber

NFC: Not-Fiber-Carbohydrates

ADF: Acid Detergent Fiber

ADIN: Acid Detergent insoluble nitrogen

AIA: Acid insoluble ash

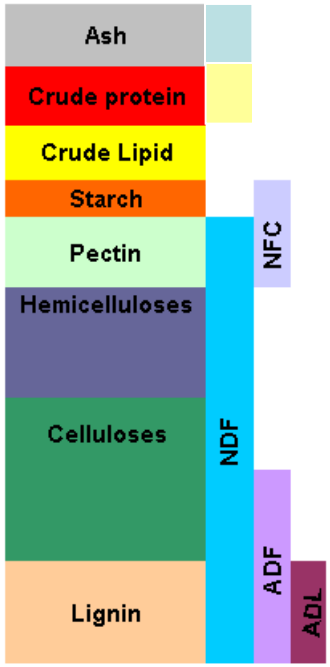
ADL: Acidic Detergent Lignin

Special Measurements: Component Analytics

Raw materials

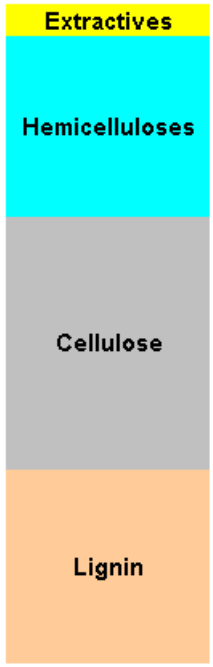
Waste

Van-Soest Analysis



Wood

Classic Wood Analysis



NDF: Neutral Detergent Fiber
NFC: Not Fiber Carbohydrates
ADF: Acid Detergent Fiber
ADL: Acid Detergent Lignin

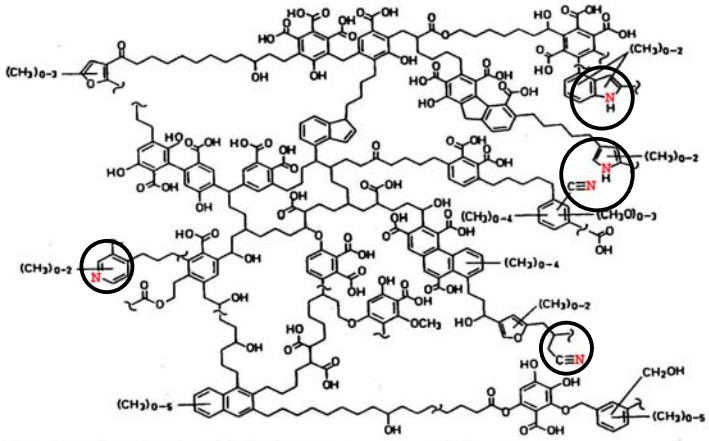
Residues

Formation of:

-humic substances with immobilization of various component fractions

-various microbial biomass compounds

Makes analytics even more complicated !



Example: Humic acid from soil model

Characterization requirements

Example: Digestates for direct application in agriculture

Parameters to avoid harmful impacts

MISSING:
CH_4 emission potential

Parameters important for transport & distribution

Parameter to describe value-added properties

MISSING:
humus compounds
nitrogen compounds

Important: short, medium, long term availability of C & N

Quality demands regarding BGK

	Digestates	
	Solid	**Liquid**
Hygienics	**Hygienization demanded**	
Impurities (>ø2 mm)	**≤0,5 % DM**	
Stones (>ø5 mm)	**(<3 % DM)***	
Degree of Digestion	**≤1500 (≤ 4000)* mg organic acids / L FM**	
Dry matter (% FM)	**(≥ 20)***	**(<12)***
Organic matter (% DM)	**≥30 (40)***	**≥ 40**
Odour	**Free of unpleasant odour**	
Heavy metals	**Regarding biowaste and fertilizer guidelines**	
Particle Size	**(compact/ spreadable)***	**(pumpable)***

** (Last years values)*

Additional declarations: bulk density, mass or volume, pH, salt content, N, P_2O_5, K_2O, MgO, S, micronutrients, CaO

Summary & conclusions

Various substrates; biorefinery types; residues; options to use residues

→ Various characterization goals

Basic characterization parameters: water, organic, ash

Problems: sampling; methods for practise missing

Special characterization parameters: component analytics

Problems:

→ different procedures in different science areas

→ residue parameters more complex compared to input parameters

Future demands:

- Application-adapted parameter definitions (hazards, handling, value)
- Standardized procedures (method book)
- New methods (easily, medium, hardliy available C and N)
- Easy, cheap, quick methods (organic, ash, water)

Our biorefinery projects

Bundesministerium für Bildung und Forschung

BIO RAFFINERIE 2021

Bioraffinerie der Zukunft

Pilot project „Lignocellulosic Bioreffinery“

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BMBF-project BERBION (2009-2013):
Efficient material and energy generation from urban organic waste and waste water

Soon: http://www.berbion.de/

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