Primary Paper Sludge Hydrolysis by Live Cellulolytic Microorganisms for Economically Feasible Biogas Production

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www.episomebiotech.com

Primary Paper Sludge

- Paper Sludge: 50 Million Tons/Year
- High Disposal Cost (~40 Euro/Ton)
- Legal Limitations about Landfill and Incineration
- Wet!

Primary Paper Sludge

- Paper Sludge: 50 Million Tons/Year WorldWide
- Fibers (Cellulose) + Fillers + Minor plastic residues
- More Environmental Awareness = More Recycled Paper = More Sludge!!

Primary Paper Sludge Characteristics

Table 1 Composition of kraft paper mill and corn stover.

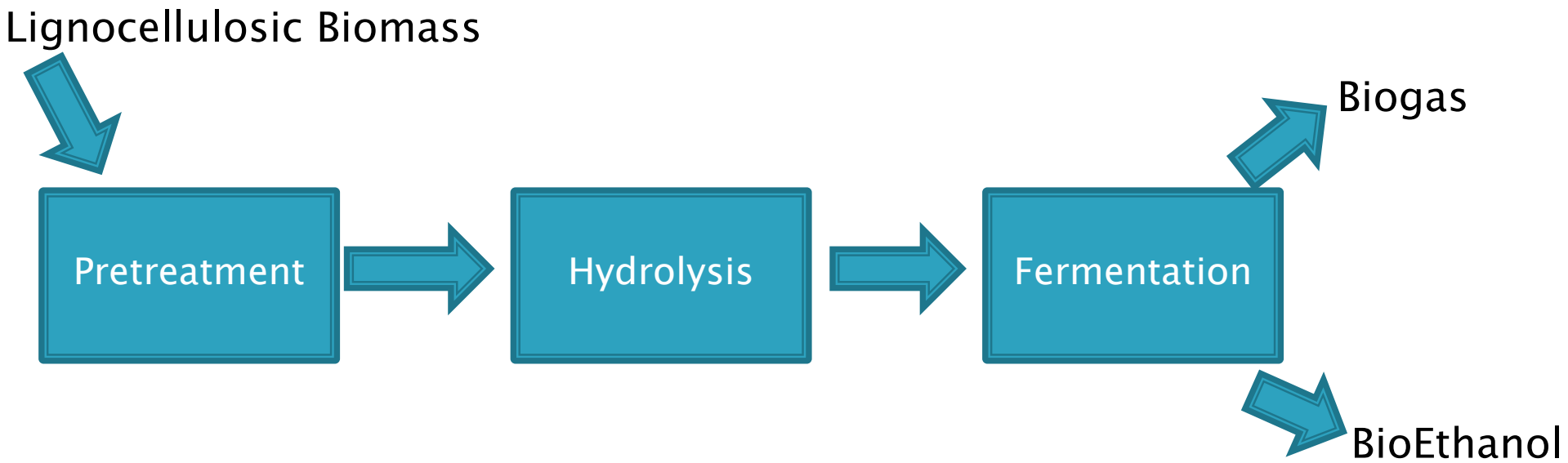
	Primary sludge	Recycle sludge	Corn stover
Glucan (%)	44.5	49.6	36.1
Xylan (%)	9.9	13.7	21.4
Lignin (%)	8.1	4.6	17.2
Total ash (%)	36.0	30.0	7.1
Acid-soluble ash (%)	26%	22%	-
Acid-insoluble Ash (%)	10%	8%	-
Others (%)	1.5	2.1	18.2
Alkalinity (milliliters of 1 NH_2SO_4/10 g dry sludge)	60	50	-

Data of sludges is the mean value of triplicate (n=3; SD<0.5%)

Kang, Li & Wang, Wei & Y Lee, Yoon. (2010). Bioconversion of Kraft paper mill sludges to ethanol by SSF and SSCF. Applied biochemistry and biotechnology. 161. 53-66. 10.1007/s12010-009-8893-4.

Approach

Biofuels from Lignocellulosic Substrates



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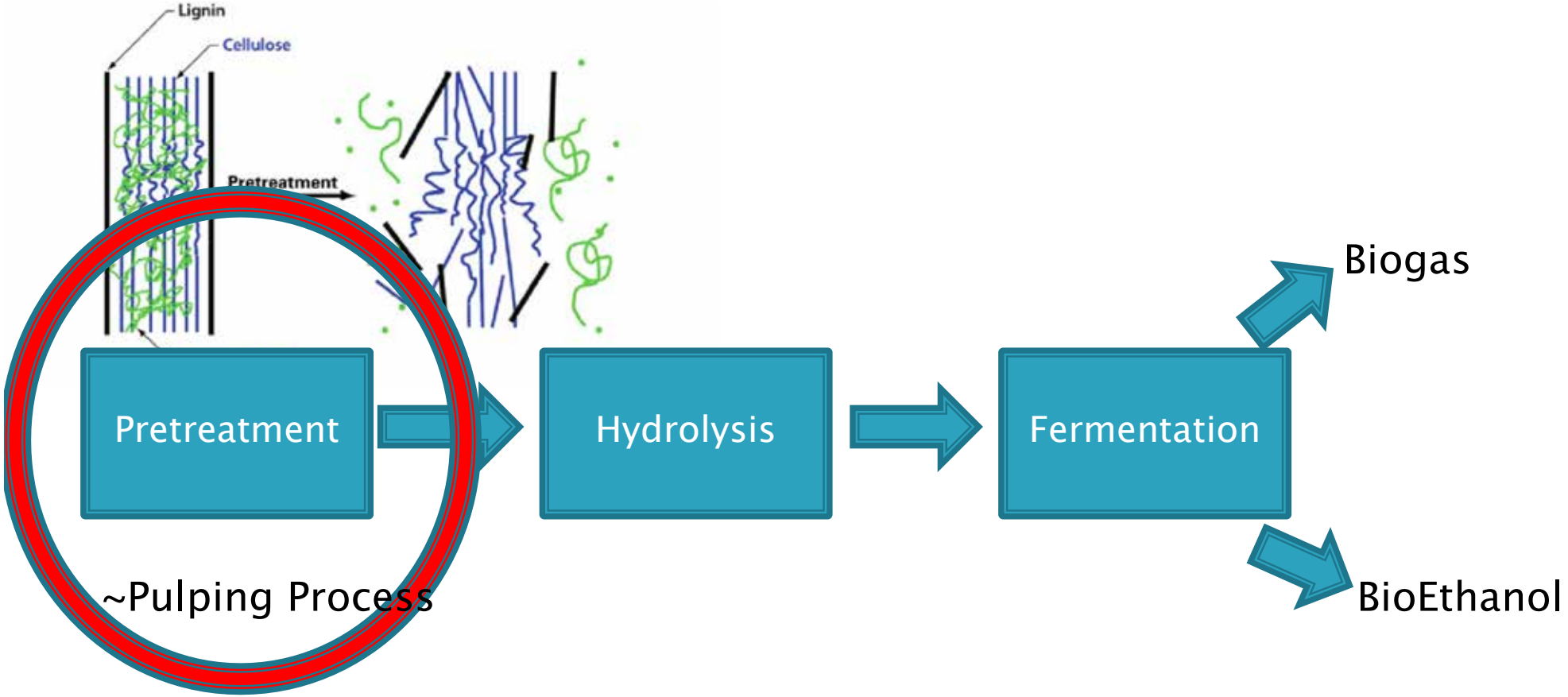

Ji, Xiao-Jun & Huang, He & Nie, Zh & Qu, Liang & Xu, Qing & T Tsao, George. (2012). Fuels and Chemicals from Hemicellulose Sugars. Advances in biochem engineering/biotechnology. 128. 199-224. 10.1007/10_2011_124.

Approach

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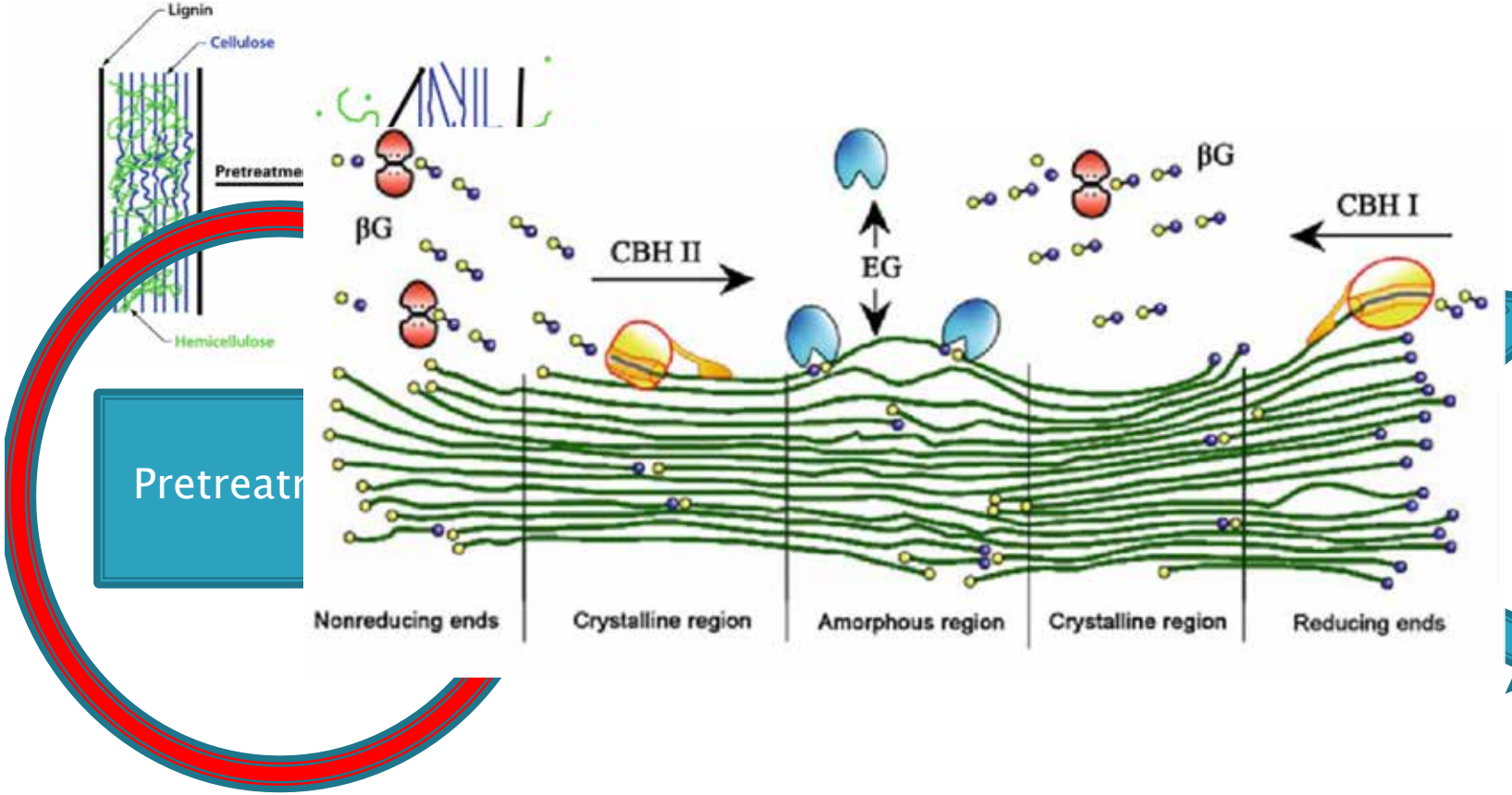


Biogas

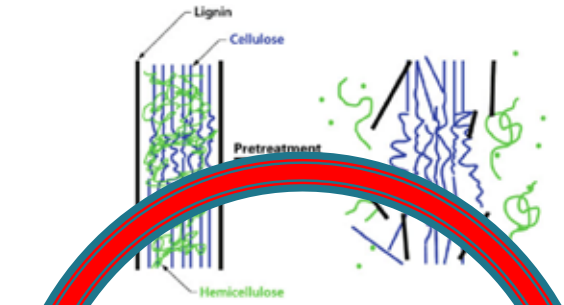
BioEthanol

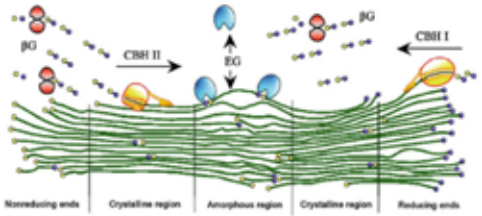
Pulping Process

Wang, Mingyu & Li, Zhonghai & Fang, Yu & Wang, Lushan & Qu, Yinbo. (2012). Cellulolytic Enzyme Production and Enzymatic Hydrolysis for Second-Generation Ethanol Production. Advances in biochemical

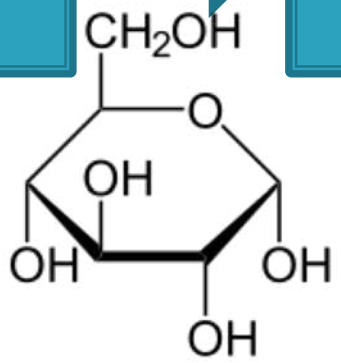
Approach

Biofuels from Lignocellulosic Substrates





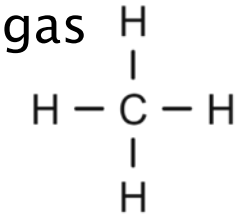
Pretreatment → Hydrolysis → Fermentation



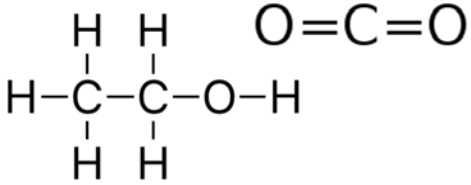
Pulping Process

O=C=O

Biogas



BioEthanol



Challanges

- Slow Digestion (Anaerobic Cellulolytic Microorganisms Required) – Contact Dependent Hydrolysis
- High viscosity / Mixing,Foaming, Floating
- Behaves as a Solid at 10% TS.
- High Enzyme Costs
- $CaCO_3$ prevents acidification

10% Total Solids

Solutions

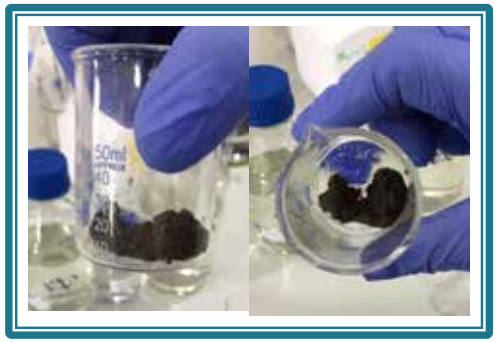
- Slow Digestion (Anaerobic Cellulolytic Microorganisms Required) – Contact Dependent Hydrolysis
- High viscosity / Mixing, Foaming, Floating
- Behaves as a Solid at 10% TS.
- $CaCO_3$ prevents acidification
- High Enzyme Costs

Pre-Digesting

Use Neutral Process

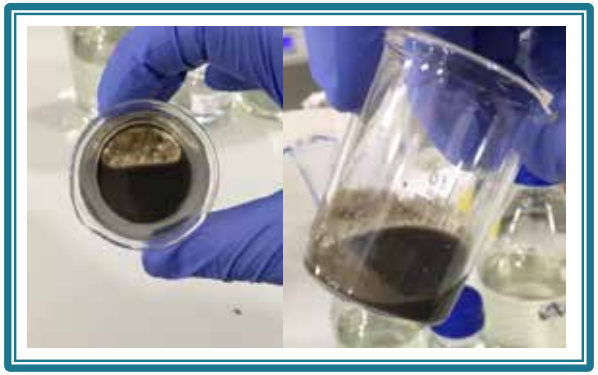
Live Microorganisms

EpiCellulyse XT – Concept



Primary Paper Sludge
Unsuitable for Biogas Process
Hard to Digest
Solid like Behaviour

Epicellulyse XT



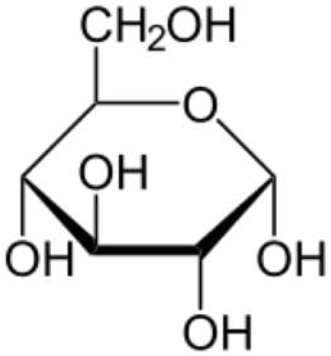
Hydrolyzed Paper Sludge
Suitable for Biogas Process
Already Digested
Liquid Characteristic–
Pumpable Mixable

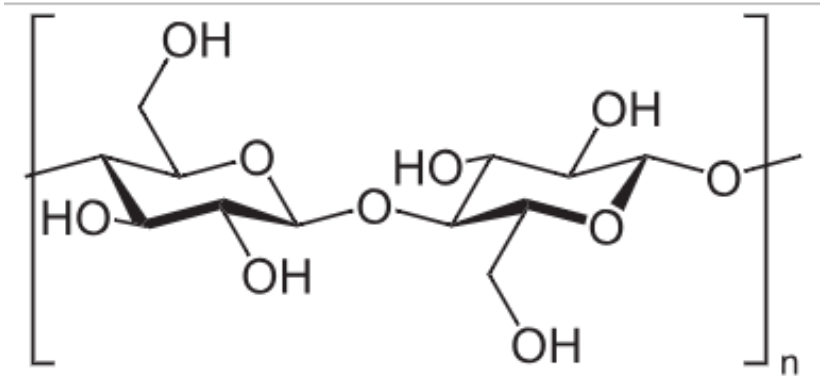
BIOGAS

PRODUCTS
Biogas & Fertilizer

EpiCellulyse XT

- Biological Hydrolytic Pretreatment Method for Primary Paper Sludge for Feasible Biogas Production
  - Novel Machinery
  - Optimised Microorganisms
  - Feasible Process Conditions





Microorganism

- Cellulolytic Gram Positive Bacteria
- Aerobic – Free Cellulase System
- Slightly acidic (pH 6)
- Mesophilic (~37 C)

Epicellulyse XT Process

- Submerged Fermentation vs Solid State Fermentation

Submerged:

- Easier to pump and mix
- Easier to control pH and temperature
- Impossible to aerate
- High water consumption
- High energy costs

Solid State:

- Hard to pump and mix
- Hard to control pH and temperature
- Easy to aerate
- Low water consumption
- Lower energy costs
- Increased Surface/Volume Ratio

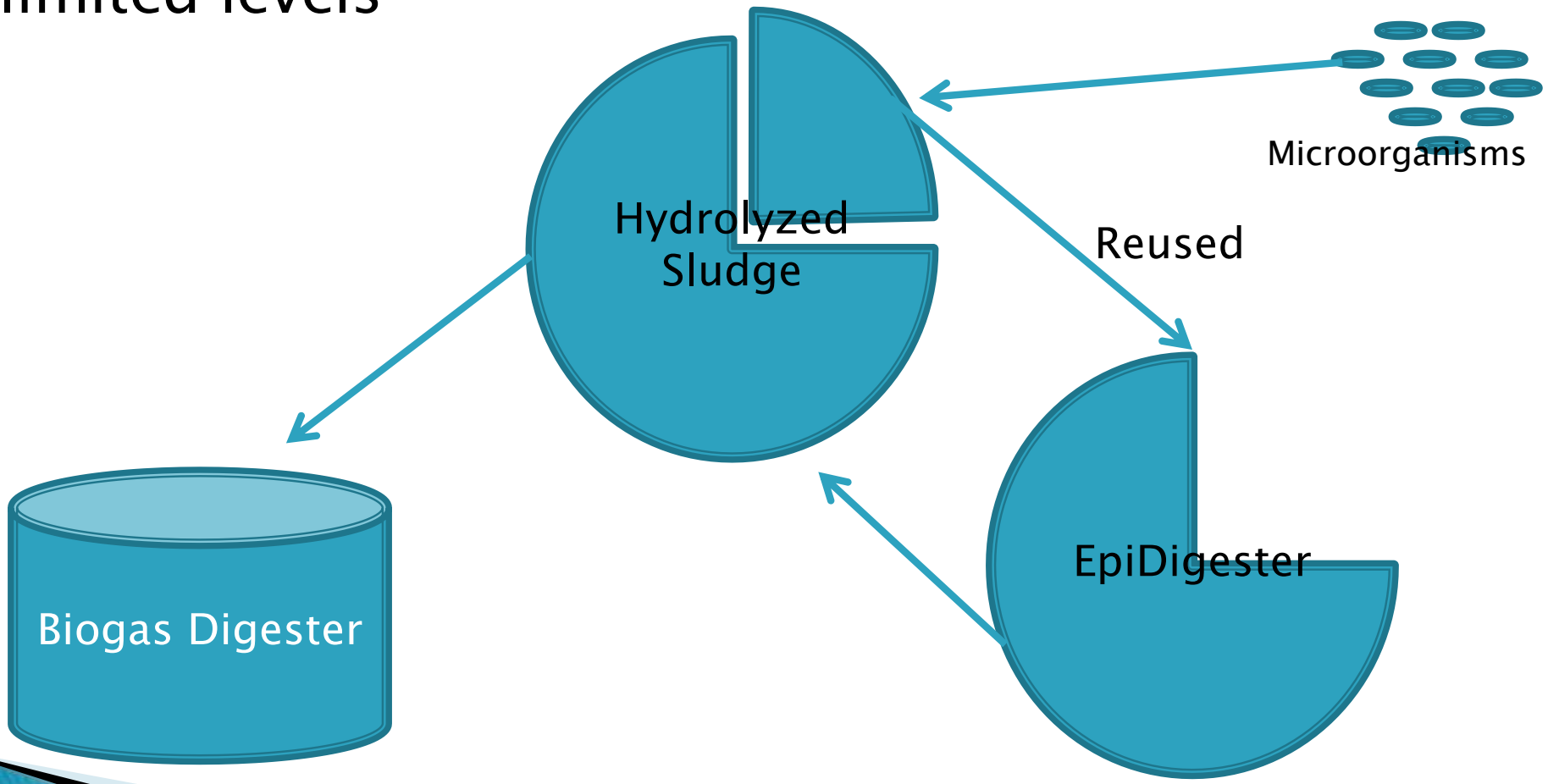
Machinery

Lab System

Pilot Plant

Recycling

- Part of enriched sludge is reused
- Microorganism supplementation is kept at limited levels



Epicellulyse XT Process

- Microorganisms
- Recycled hydrolyzed sludge
- Supplements to keep microorganisms happy
- Humidity
- Surfactants

10% Total Solids

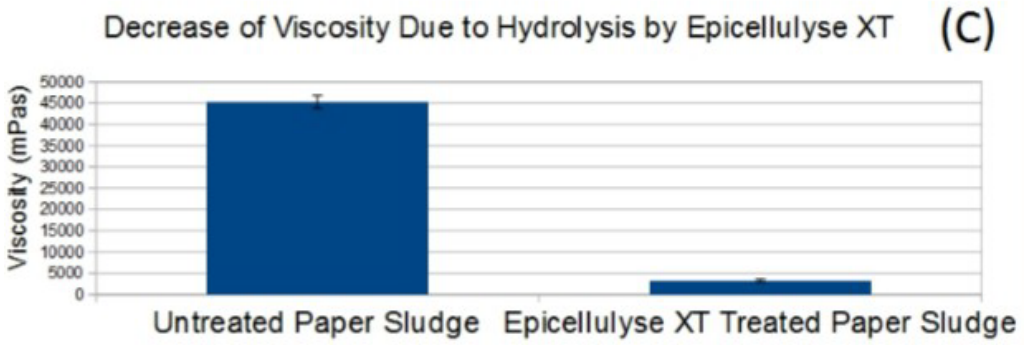
Ready to send to Biogas Digester

Unprocessed

Processed with Epicellulyse XT

Deinking Sludge from Viking Paper, Turkey

Results



Trial	Pilot
HRT	24 Days
Methane Ratio	55%
CH4/g VS	246.6 ml (300 ml in LabScale)
H2S	~50-200 ppm
N-Source	Urea

Pilot Plant

Located in Modern Karton, Wastewater Treatment Plant, Corlu, Tekirdag, Turkey

Conclusions

- Epicellulyse XT utilizes cellulolytic bacteria for cellulose hydrolysis
- Primary paper sludge is liquified and is usable in CSTR type reactors
- Glucose is not the end product!
- Main advantages are:
  - Reusable, live microorganisms
  - Solid State Fermentation
  - Low working temperature

Thanks for listening!

Less chemicals

More Biology!

episome

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