



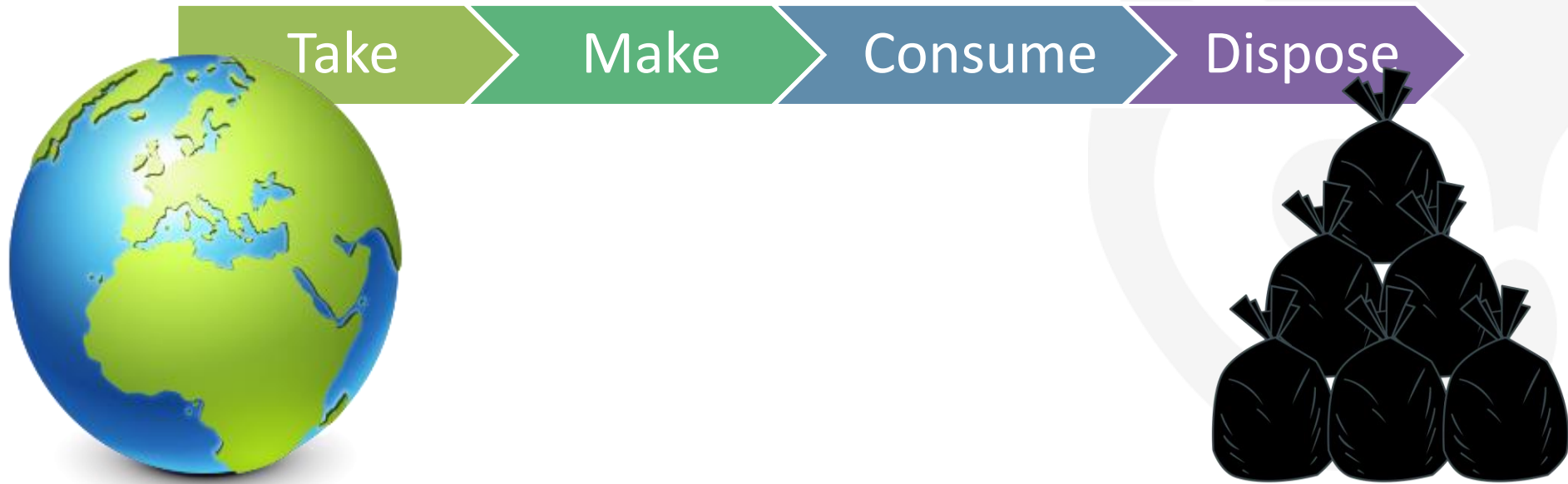
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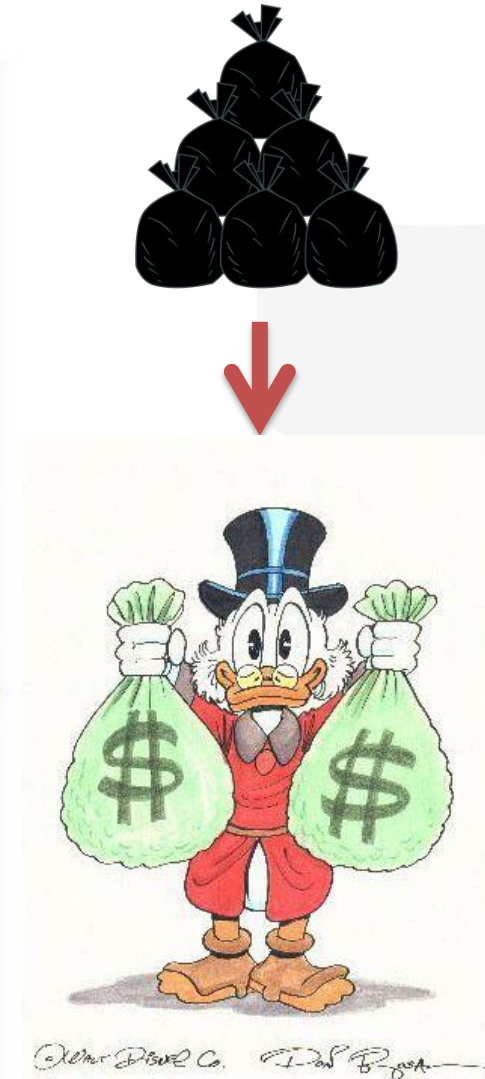
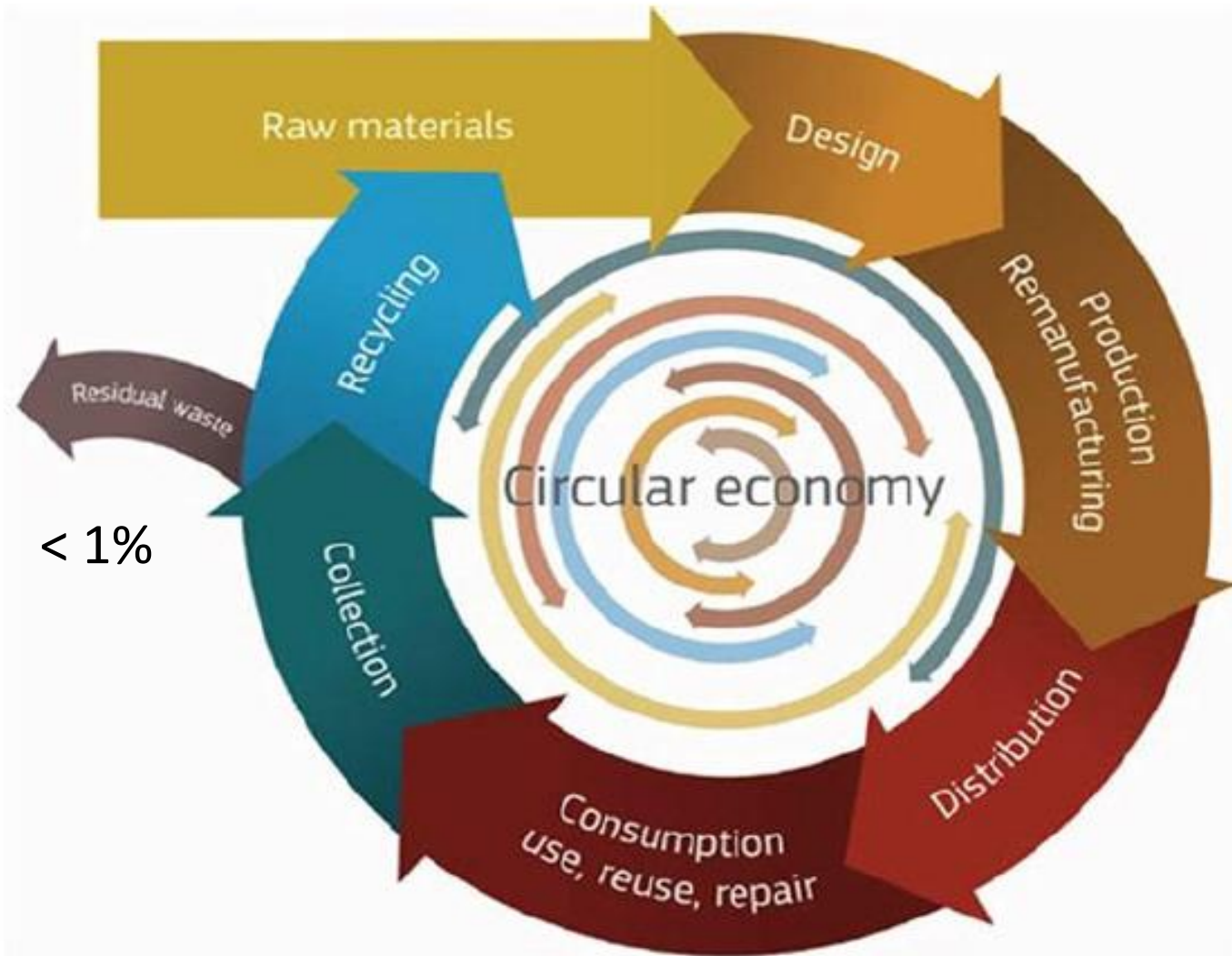
**CREATING SUSTAINABLE  
FIBRE SOLUTIONS**

# **CIRCULAR ECONOMY IN MOTION FOR THE PBI: CASE OF PHA AND ALGINATES**

# Linear Economy



# Circular Economy



# Vision of the Dutch PBI

"The paper industry is the **centerpiece** of a Biomass-based **Circular Economy**. We make **the most** out of **Biobased raw materials** and hereby **reduce energy** consumption and **CO<sub>2</sub>** emissions and **increase** the **added value** and customer value **of products** and services.  
Our people make the difference."



# Vision of the Dutch PBI

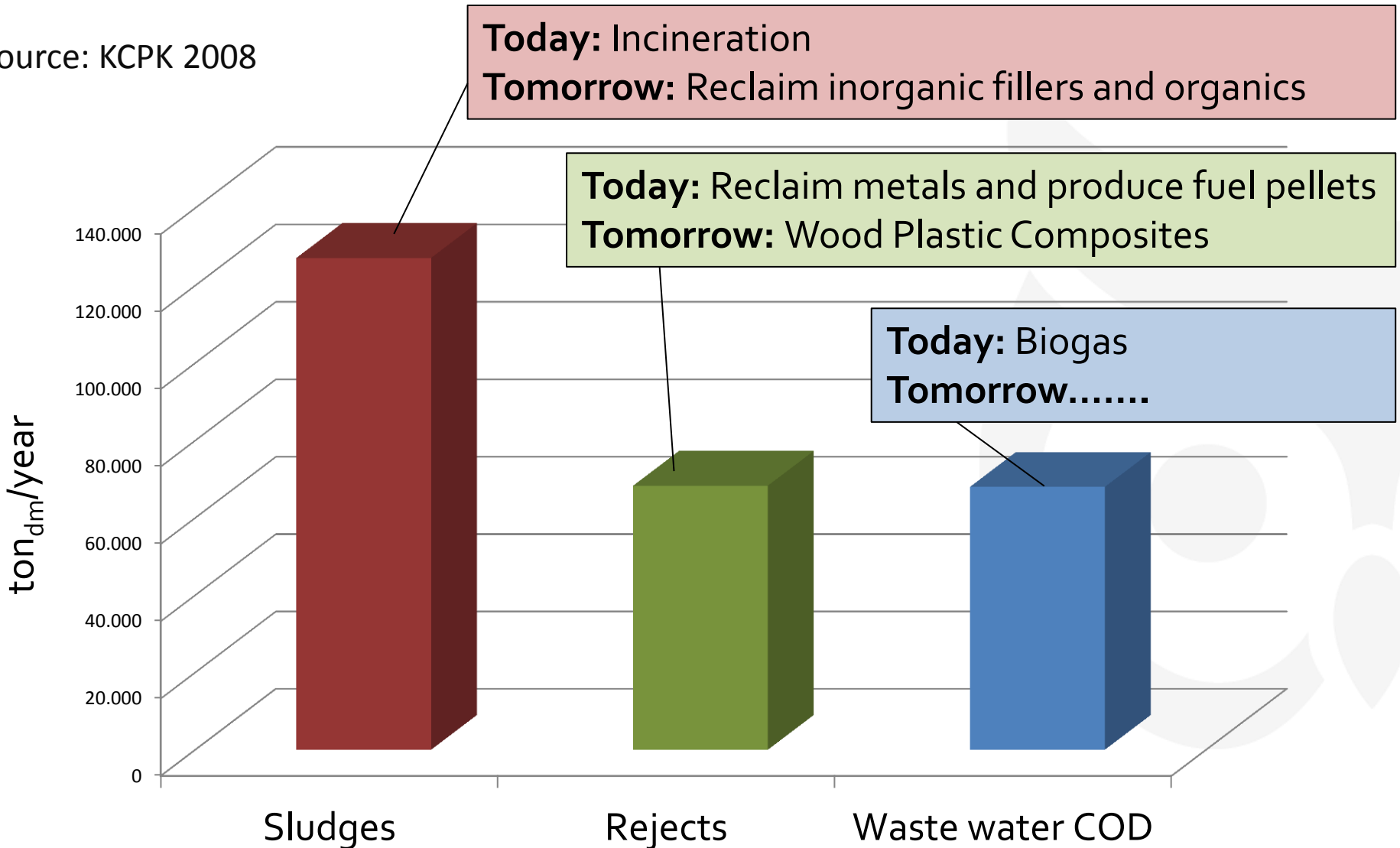
**Vision 2020** is to have  
100 % closed product Biobased cycles:

- Full use of raw materials
- 100 % positive reusability or recyclability of all components

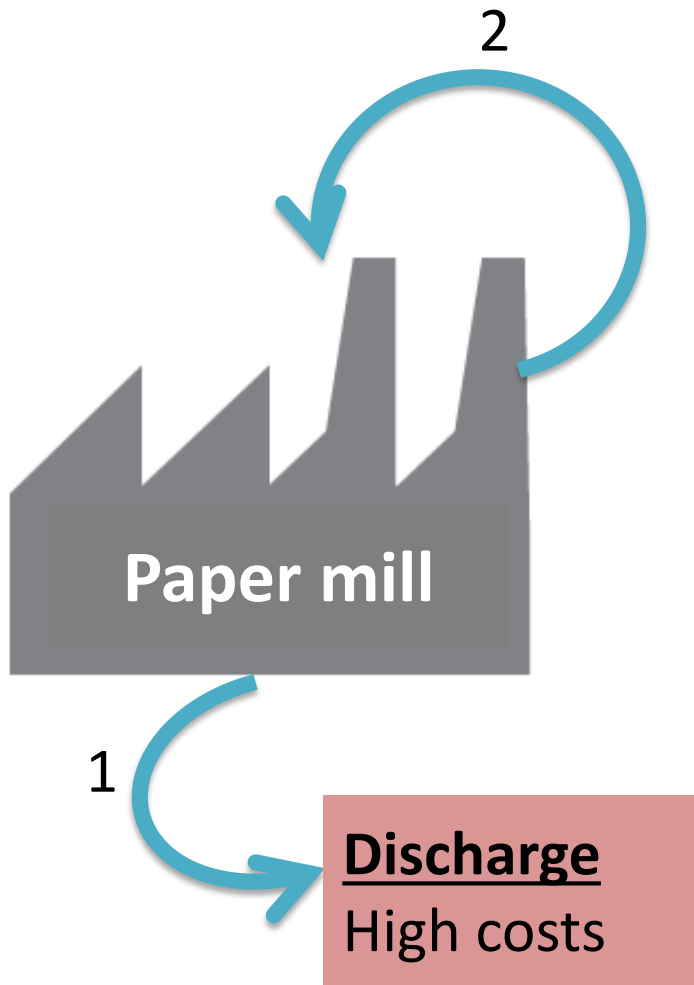


# Valorization of sidestreams from Dutch PBI

Source: KCPK 2008



# Options for Wastewater

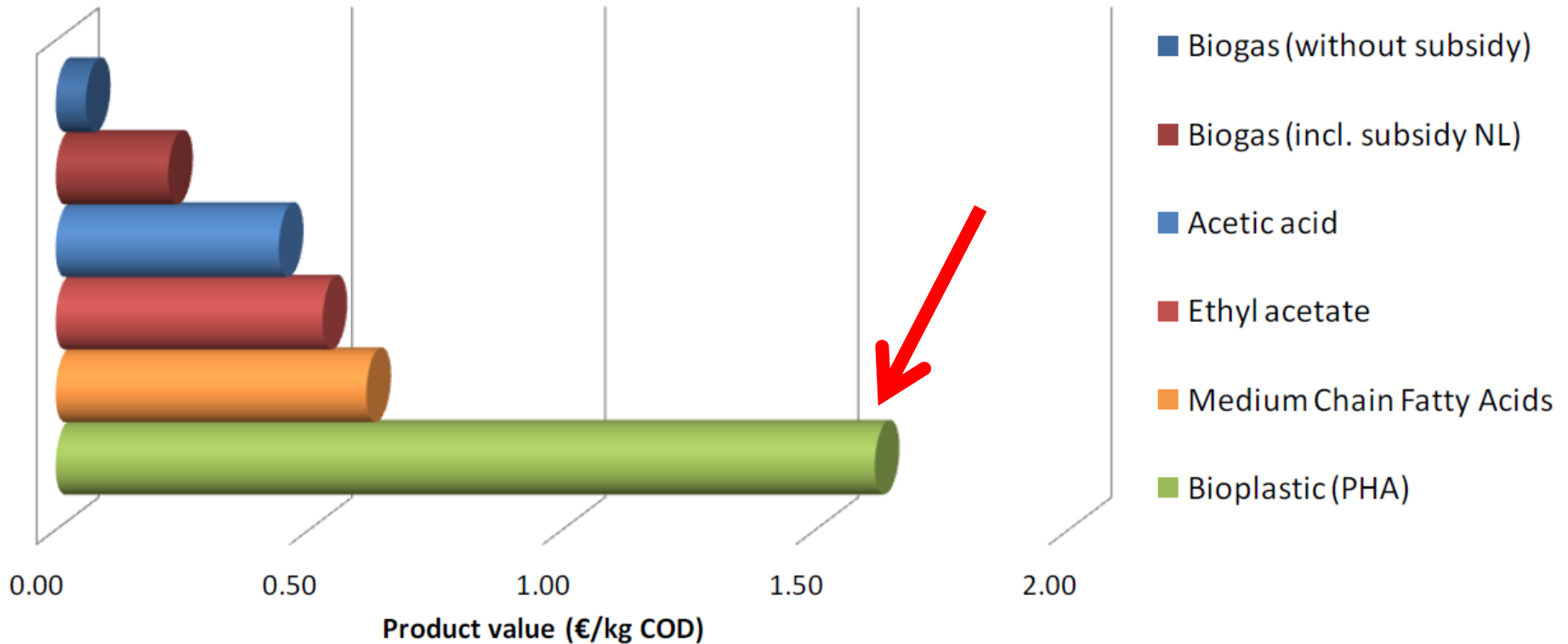


2a. Biocides + reuse water:  
High COD/High Costs

2b. Produce Biogas:  
Low COD/  
Marginal profit

2c. Produce Biopolymers:  
Low COD/  
New products with added  
value

# Valorisation of COD



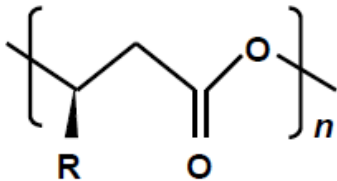
Source: **PAQUES**



# Polyhydroxyalkanoates (PHA)

# PHA

- Bioplastic from the family of polyesters (e.g. PET)
- Good moisture and gas barrier
- Excellent film forming and coating properties
- Good biodegradability



## PHA

PHB  
PHV  
PHBV

PHBHx  
PHBO  
PHBD  
*etc.*

## R group

$-\text{CH}_3$   
 $-\text{CH}_2\text{CH}_3$   
 $-\text{CH}_3, -\text{CH}_2\text{CH}_3$

$-\text{CH}_3, -\text{CH}_2\text{CH}_2\text{CH}_3$   
 $-\text{CH}_3, -(\text{CH}_2)_4\text{CH}_3$   
 $-\text{CH}_3, -(\text{CH}_2)_6\text{CH}_3$



# Opportunities with PHA

- Close water loop without adding biocides
- Solve problem of COD accumulation
- Savings from closing the water loop
- Application in paper products - **biodegradable packaging**
- Produce products with added value

**ANOXKALDNES**

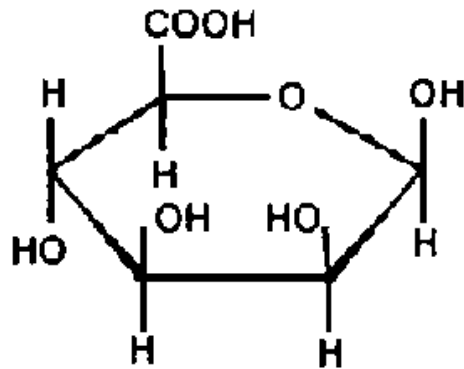
**PAQUES**

**OPURE**  
zuiver advies

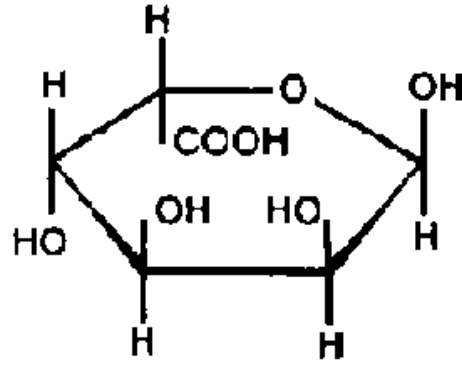
# Alginates (Alginic acid)

# Alginates

- Anionic polysaccharides present in brown algae



$\beta$  - D - Mannuronic Acid



$\alpha$  - L - Guluronic Acid



- Excellent surface sizers and enhance grease resistance, oil resistance, and printability
- Interesting film forming and coating properties

# Opportunities with Alginates

- Close water loop without adding biocides
- Savings from closing water loop
- Application in paper products – **sizing agent, coating...**
- Product with added value

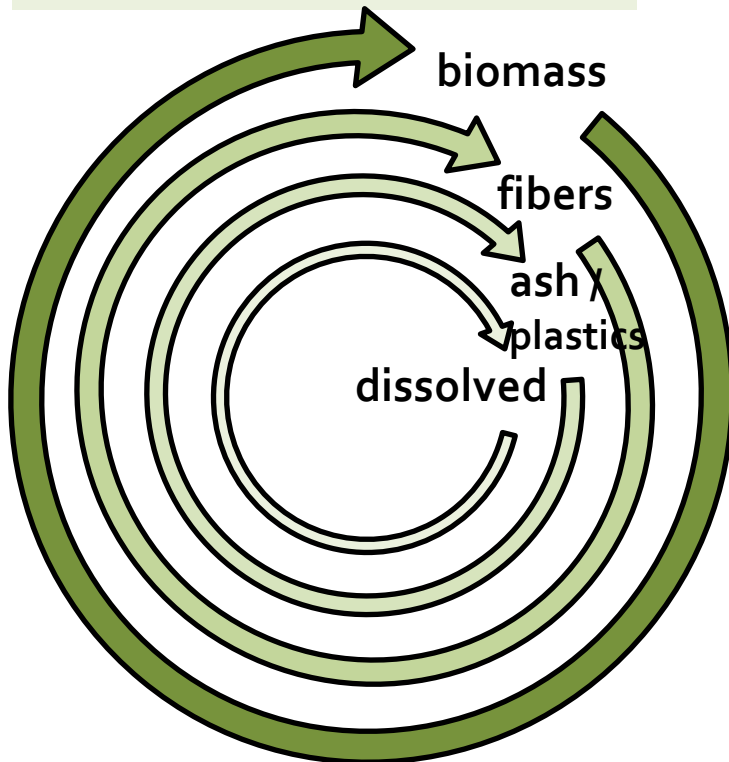


# Summary: Towards full use of all components

## Full use of biomass:

- (cellulose) fibers
- hemicellulose
- lignin
- Proteins, sugars, fats
- Nutrients, etc.

On location or elsewhere.



## Reclamation of fibers:

- Paper for Recycling
- Fibers from papermaking side streams
- Fibers from materials previously considered as waste

## Reclamation of the solid fraction:

- Separation of plastics and metals from rejects
- Reclamation of inorganic fillers and fines

## Reclamation of the dissolved fraction:

- Biopolymers (PHA, alginates)
- Waste heat and energy
- Clean water

# Conclusions

We are a leading industry in **resource efficiency** but there are **still many more possibilities ahead** to convert waste from **Cost -> Profit**

Many technical possibilities ahead; economics are coming...





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