



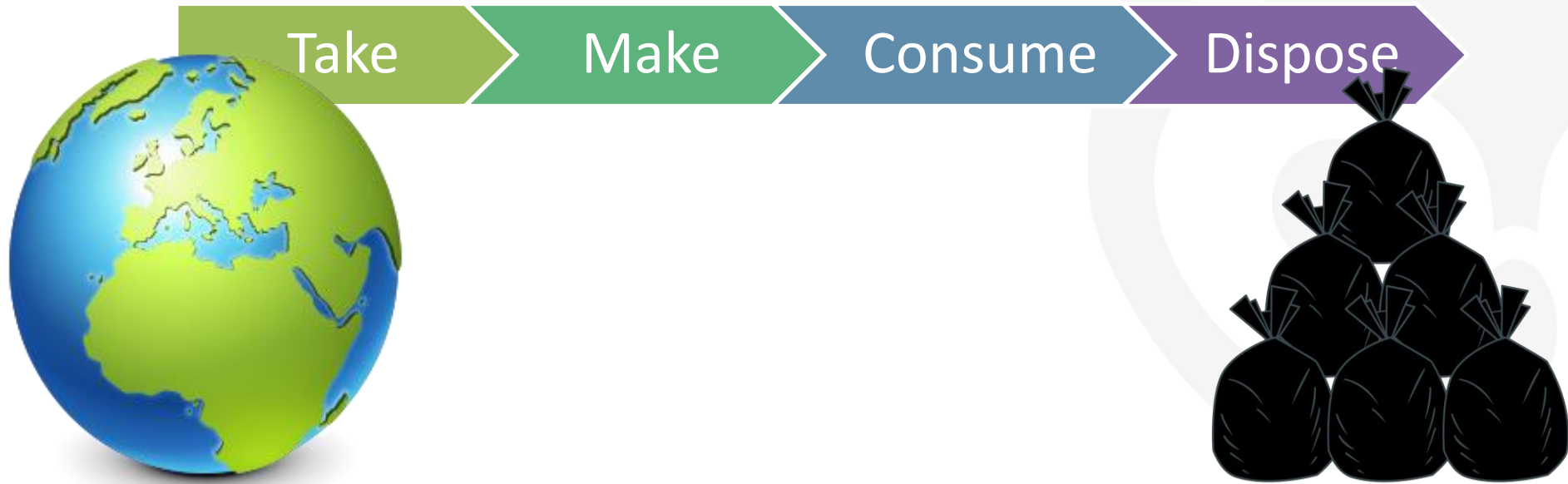
**KENNISCENTRUM
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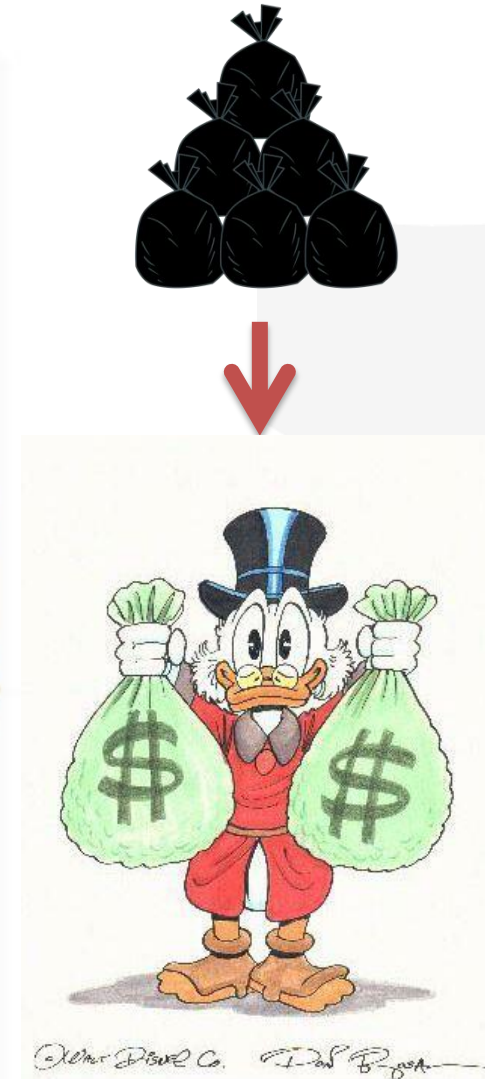
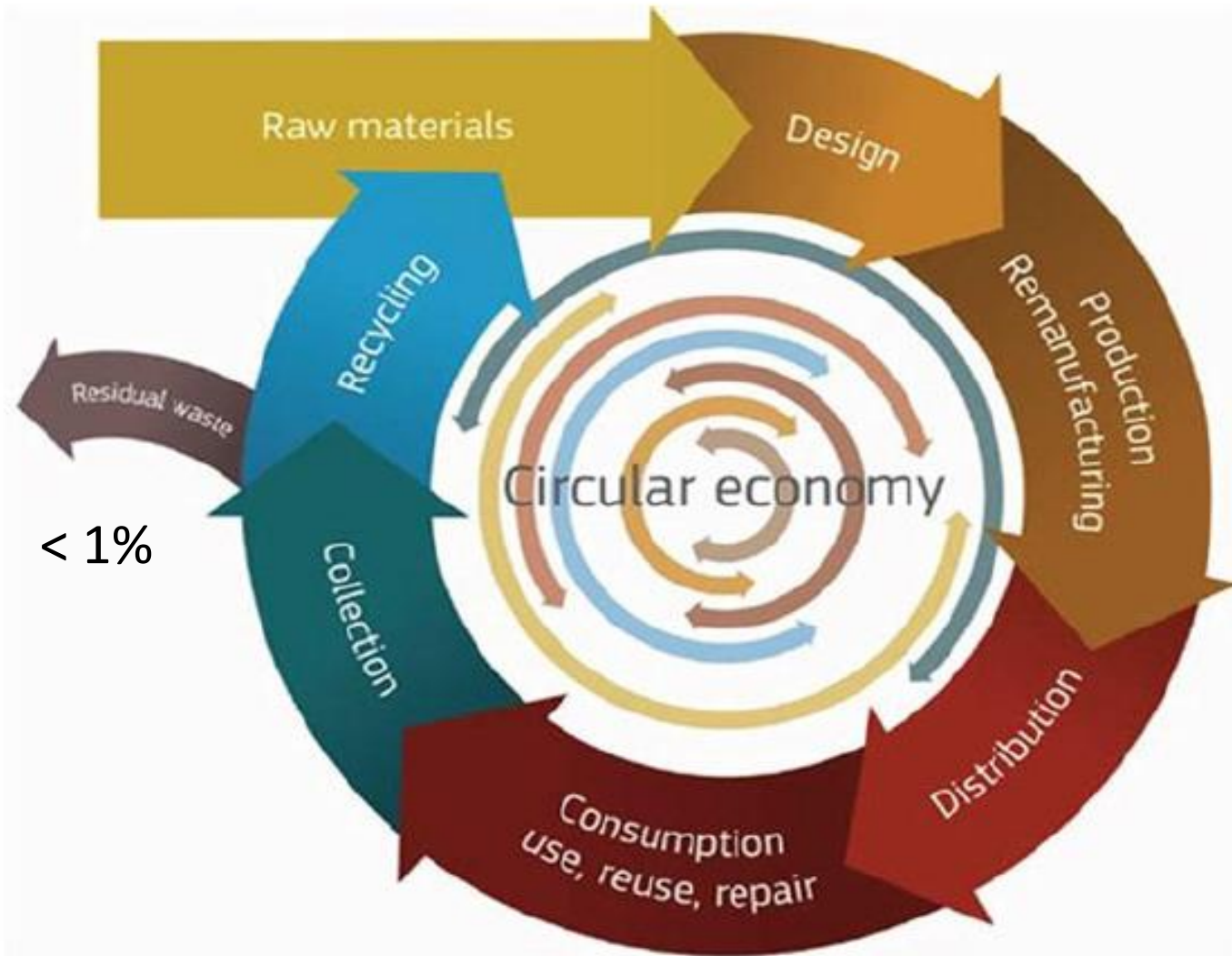
**CREATING SUSTAINABLE
FIBRE SOLUTIONS**

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 **CO₂** emissions and **increase** the **added value** and customer value **of products** and services.
Our people make the difference."



Vision of the Dutch PBI

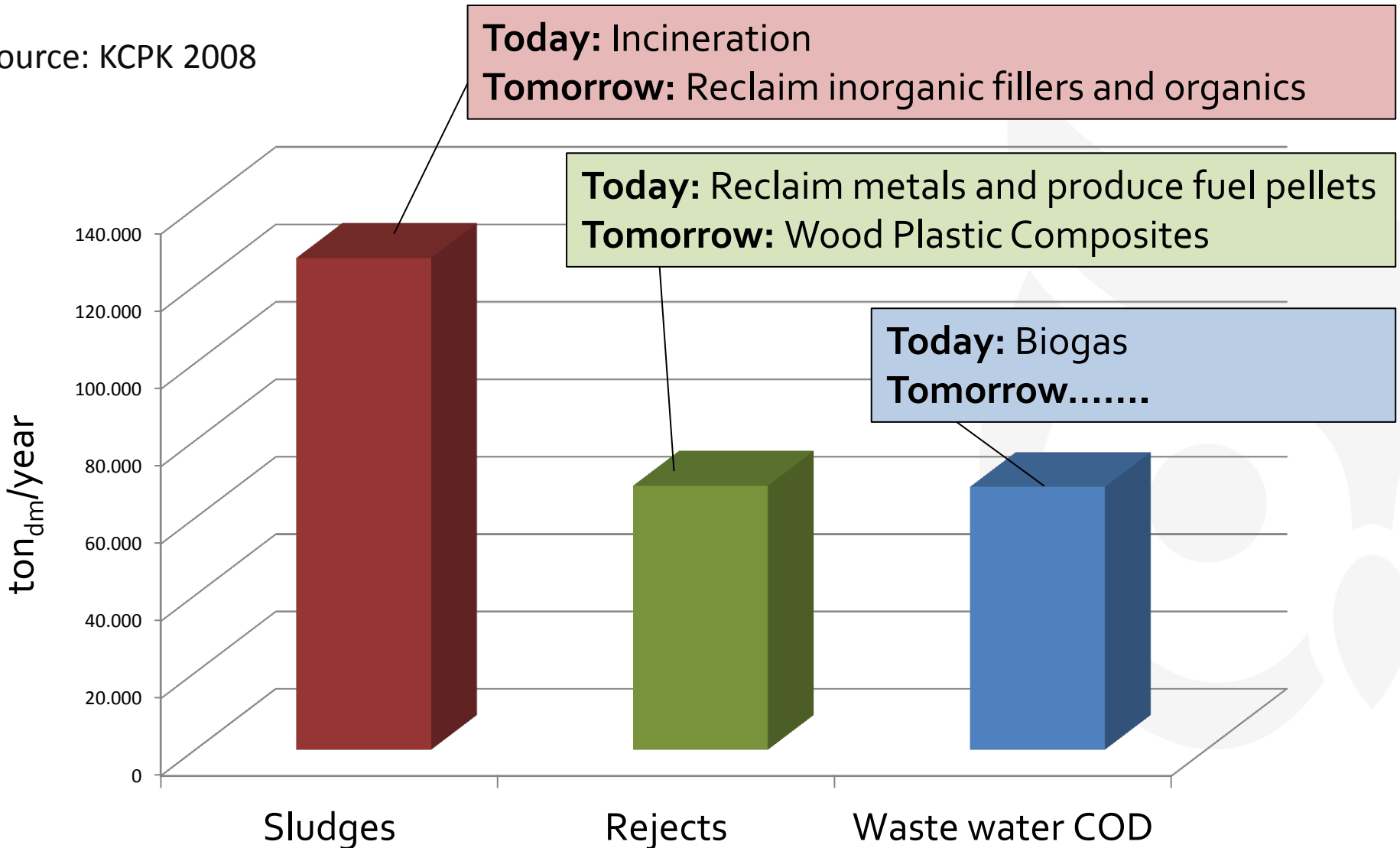
Vision 2020 is to have
100 % closed product Biobased cycles:

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

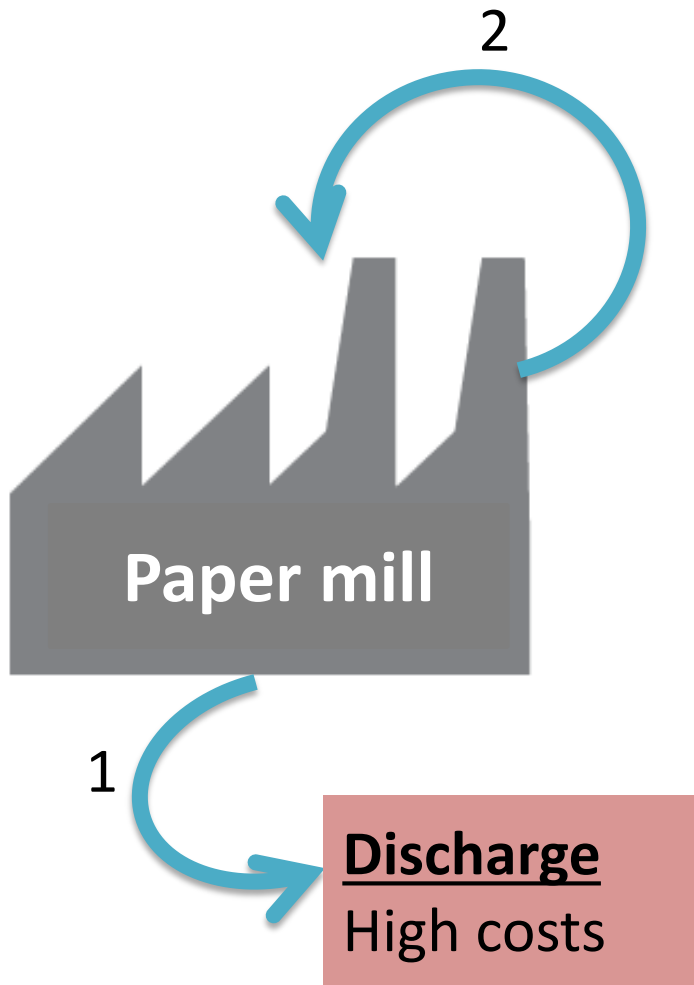


Valorization of sidestreams from Dutch PBI

Source: KCPK 2008



Options for Wastewater

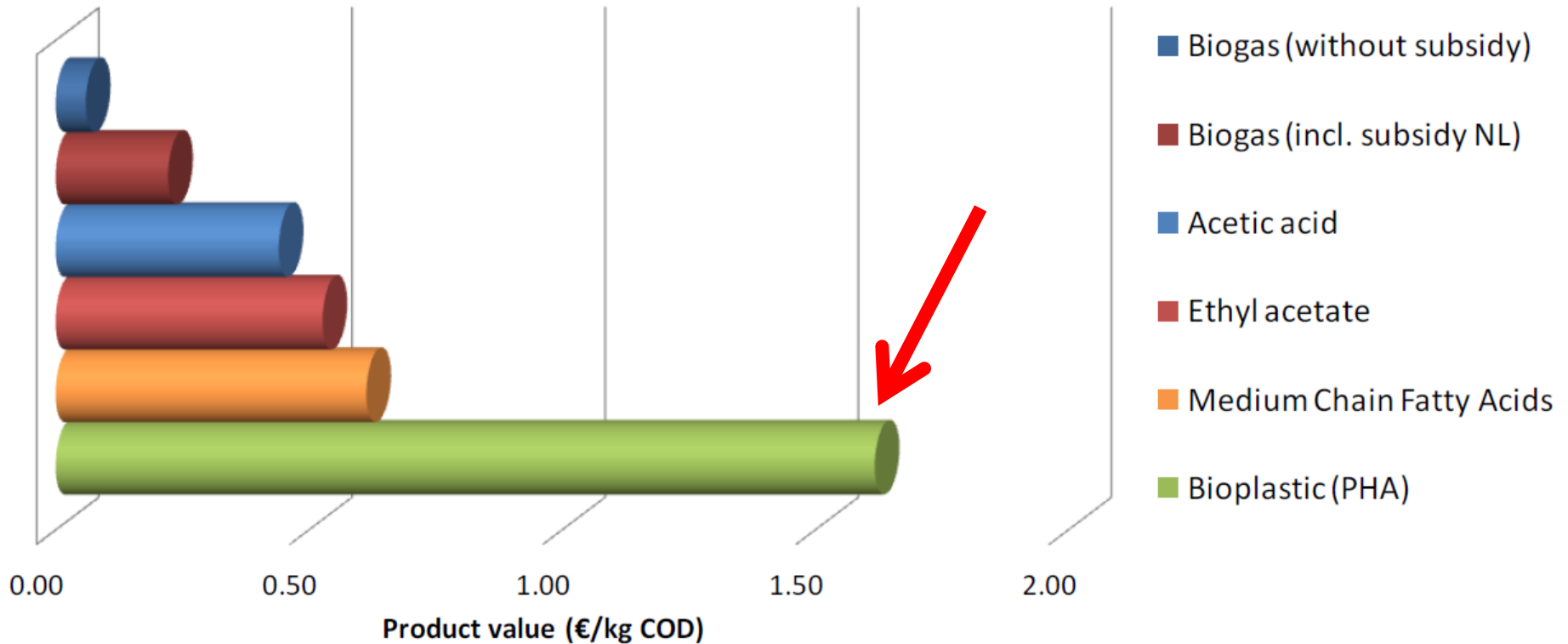


2a. Biocides + reuse water:
High COD/High Costs

2b. Produce Biogas:
Low COD/
Marginal profit

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

Valorisation of COD

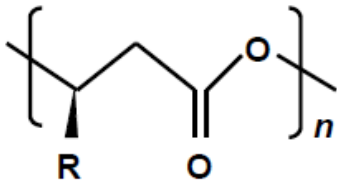


Source: **PAQUES**

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

-CH₃
-CH₂CH₃
-CH₃, -CH₂CH₃

-CH₃, -CH₂CH₂CH₃
-CH₃, -(CH₂)₄CH₃
-CH₃, -(CH₂)₆CH₃



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

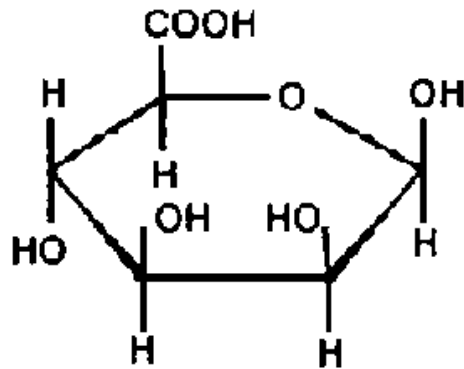
PAQUES

OPURE
zuiver advies

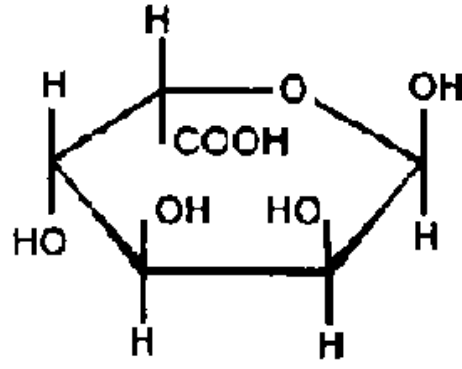
Alginates (Alginic acid)

Alginates

- Anionic polysaccharides present in brown algae



β - D - Mannuronic Acid



α - 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

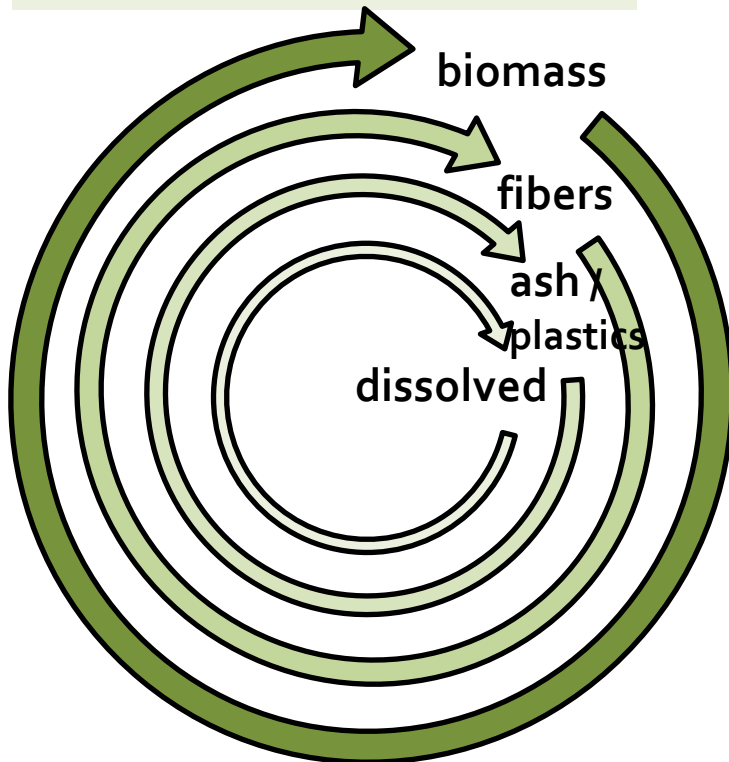


Summary: Towards full use of all components

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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