CLOSE THE LOOP: EXPLOITATION OF HALOPHYTE RESIDUES

How to close the loop of the halophyte biorefinery by conversion into biogas and biochar.

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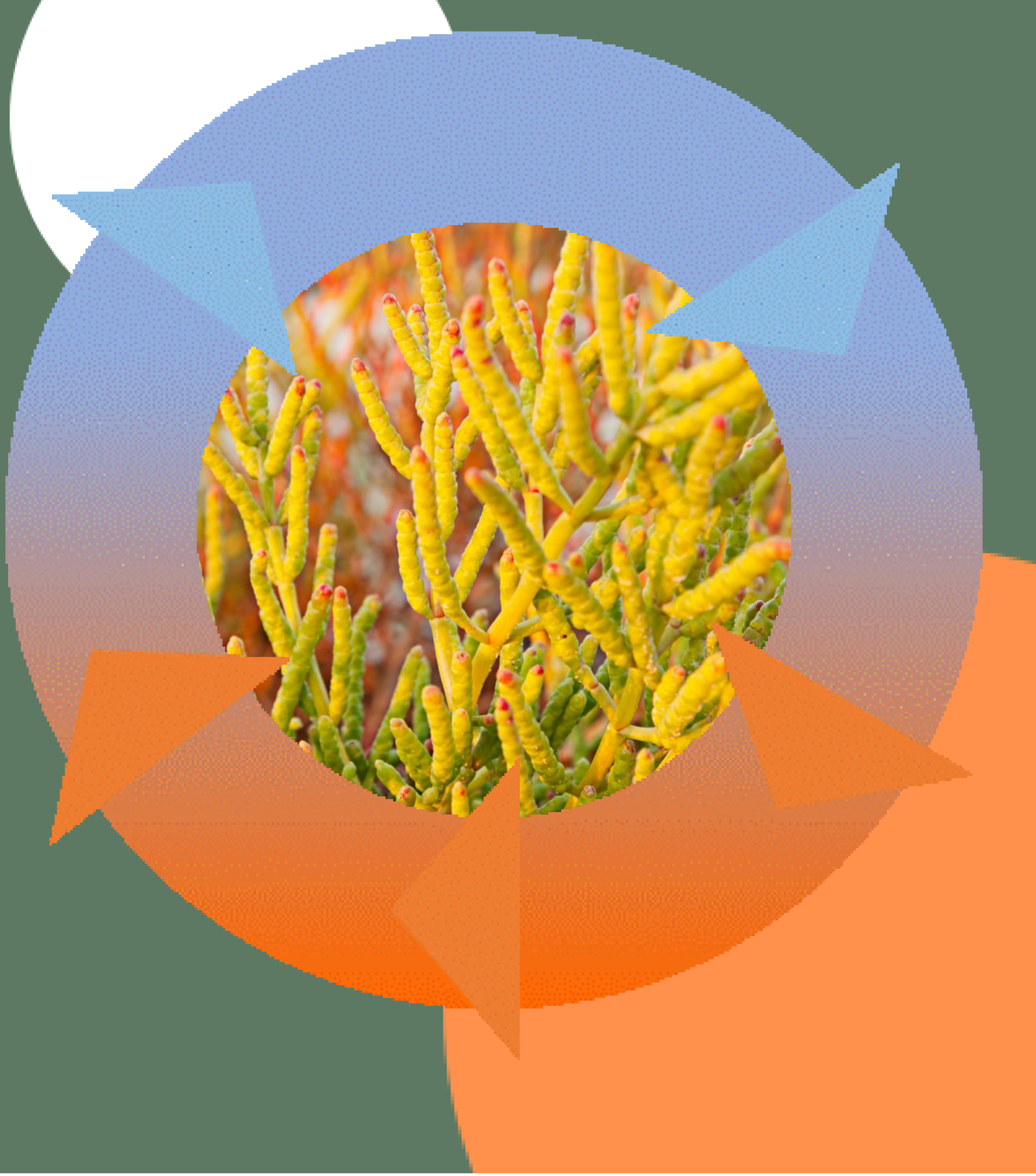
Biogas and biochar from residues of the biorefinery



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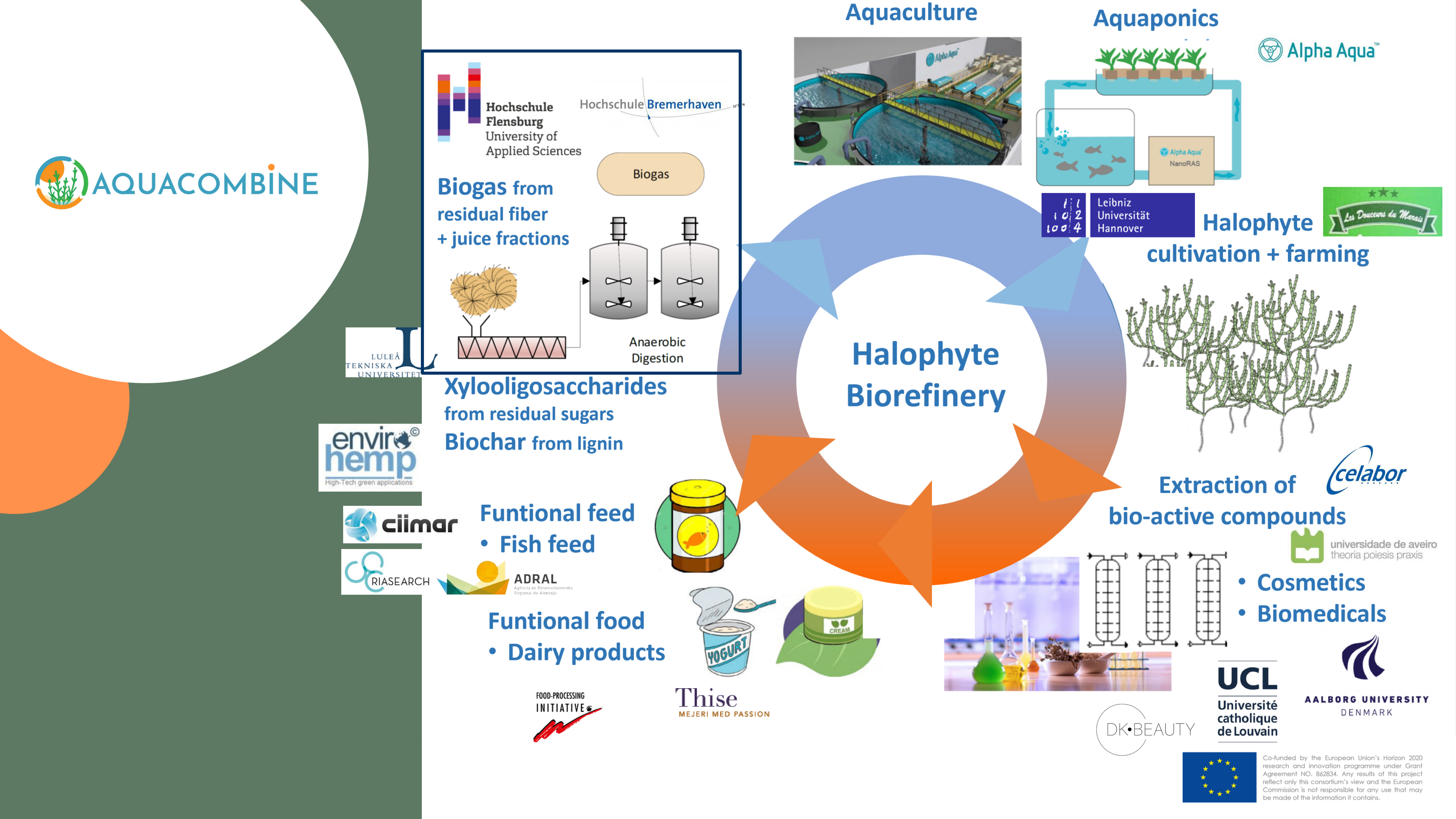

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Aquaculture
Aquaponics
Alpha Aqua
NanoRAS
Leibniz Universität Hannover
Halophyte cultivation + farming
Les Douceurs du Marais
Hochschule Flensburg University of Applied Sciences
Hochschule Bremerhaven
Biogas
Biogas from residual fiber + juice fractions
Anaerobic Digestion
Luleå Tekniska Universitet
Xylooligosaccharides from residual sugars
Biochar from lignin
envirohemp High-Tech green applications
Halophyte Biorefinery
Extraction of bio-active compounds
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Halophyte biomass

Input material for the biorefinery

Salicornia plant

Fresh tips for food

Approx. 1/3 of total biomass production

Short season for food production due to lignification of the plant

Large residue at the end of the season (Typically un-used)

Valorization of the lignified fraction of the biomass will significantly increase feasibility

Lignified plant

Not suitable as forage crop

Not suitable for soil enhancement

Approx. 2/3 of total biomass production

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Halophyte biomass

Input material for the biorefinery

Dry Halophyte straw

↓ ↓

Extractives fraction

Bioactive compounds

Antioxidants

Anti-inflammatory compound

Antimicrobials

Extractives free fibers

Fibers for biogas

Fibers for feed products (dietary fibers)

Green succulent halophyte biomass

↓ ↓

Green juice

Protein

Lipids

Carotenoids

Chlorophyll

Green pulp

Fibers for biogas

Fibers for feed products (dietary fibers)

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Halophyte biomass

Input material for the biorefinery

Residues for biogas & biochar:

Fiber material

Dry Halophyte straw

Extractives fraction

Bioactive compounds

Antioxidants

Anti-inflammatory compound

Antimicrobials

Extractives free fibers

Fibers for

biogas & biochar

Fibers for feed products (dietary fibers)

Green succulent halophyte biomass

Green juice

Protein

Lipids

Carotenoids

Chlorophyll

Green pulp

Fibers for

biogas & biochar

Fibers for feed products (dietary fibers)

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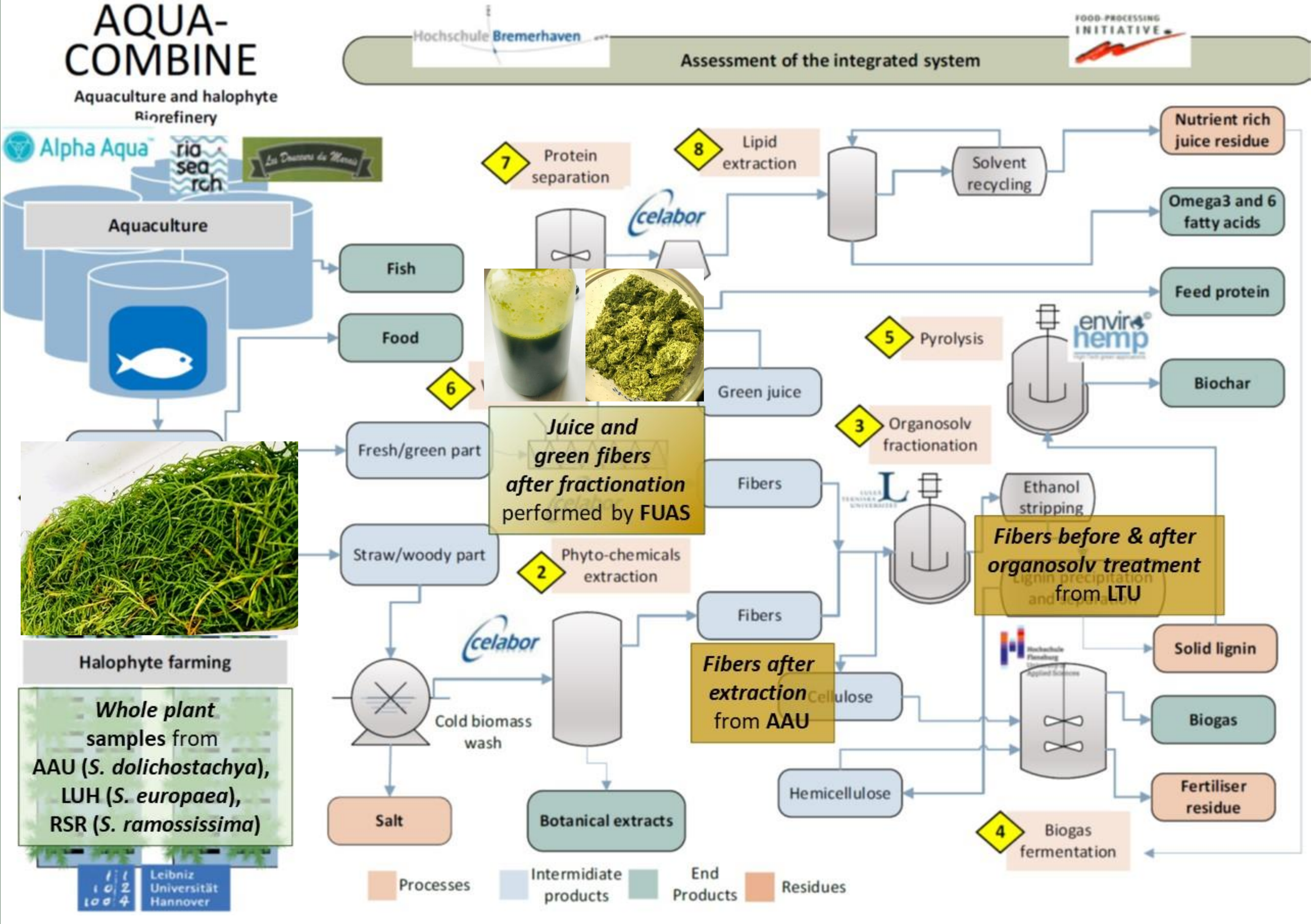
Biogas from halophytes

- Fresh halophyte plant material
  - different species
  - from different cultivations
- After “green fractionation”
  - pulp (green fibers) and juice fraction
- After extraction of bioactive compounds
- After organosolv pretreatment – separation of lignin (for biochar) and cellulose/hemicellulose (for biogas)



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Biogas from halophyte plant material – fresh plant

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- Salt concentration higher than 2.4 g/L may inhibit the biogas process
- In a non-inhibited biogas process methane yields of up to 300 mL-CH_4/g-VS were achieved (similar to grass biomass),
  equivalent to the following ***methane yields per ton***:

- *S. europaea*, dried: 109-164 m^3-CH_4
- *S. ramosissima*, fresh whole plant: 23,6 m^3-CH_4
- *S. ramosissima*, pulp fraction: 74,4 m^3-CH_4
- *S. ramosissima*, juice fraction: 7,8 m^3-CH_4
- *S. ramosissima*, dry mature plant: 149 m^3-CH_4

Halophytes can be added to 1 ton in co-digestion with non-saline biomass:

- *S. europaea*, dried: 11 – 32 kg
- *S. ramosissima*, fresh whole plant: 178 kg
- *S. ramosissima*, pulp fraction: 178 kg
- *S. ramosissima*, juice fraction: 178 kg
- *S. ramosissima*, dry mature plant: 52 kg

Biogas from halophyte plant material – after biorefining

- ***Fiber material after extraction of bioactive compounds reveal a lower methane yield***, presumably due to the higher lignocellulosic content in the remaining fiber material.

- The ***methane yield of fiber material increases after delignification by organosolv pretreatment***, which correlates to a lower lignin content of this fiber material.

- ***Sulphur content of halophyte plant material is 25-45 times higher*** (38 – 69 g/kg-TS) ***compared to grass biomass*** (1.2 – 1.8 g/kg-TS) that may cause significant H_2S production during the biogas process.

- ***Sulphur concentration was 10x lower in residual material*** after subcritical water extraction

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Biochar from lignin (after organosolv pretreatment)

- Can be used as activated carbon (for filter material etc.)

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Thank you!

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