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RESEARCH CENTER ITENE

SCALIBUR

LEADING A REVOLUTION IN BIOWASTE RECYCLING

Trailblazing to produce food grade renewable bioplastics using municipal waste activated sludge

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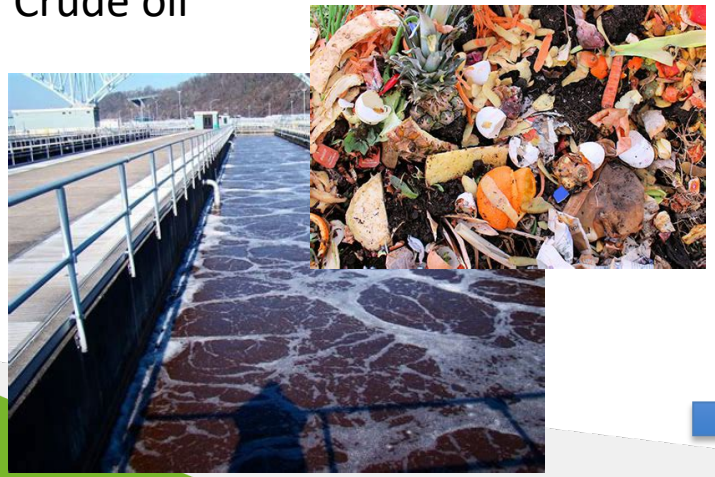
This project received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement Nº 817788

Crude oil

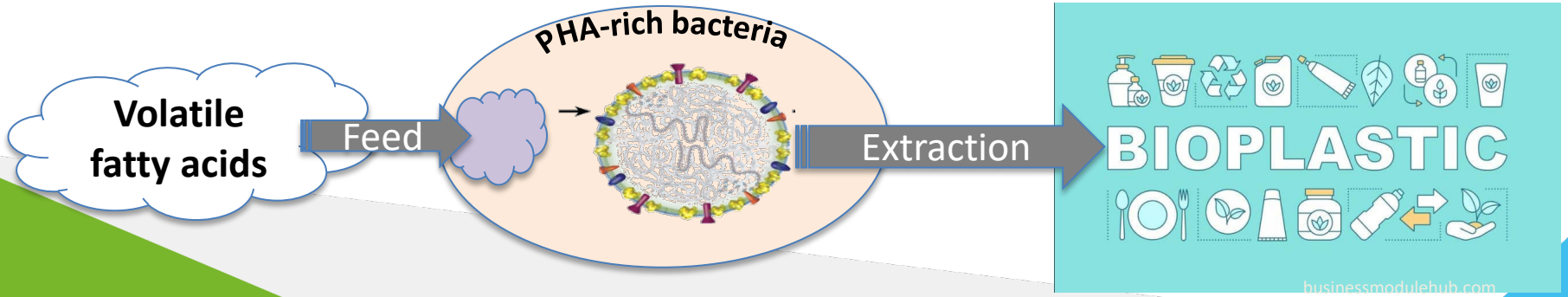


Organic waste & wastewater

NO PROBLEM

Polyhydroxyalkanoates (PHAs) from “waste”

1. Naturally occurring polyesters that are accumulated in bacteria
2. Extractable ingredients for recyclable biodegradable bioplastics
3. PHAs stored by biomass (“activated sludge”) coming from wastewater treatment
4. Wastewater treatment plants can become renewable resource factories



Contents – Waste as resource

SCALIBUR
LEADING A REVOLUTION IN BIOWASTE RECYCLING

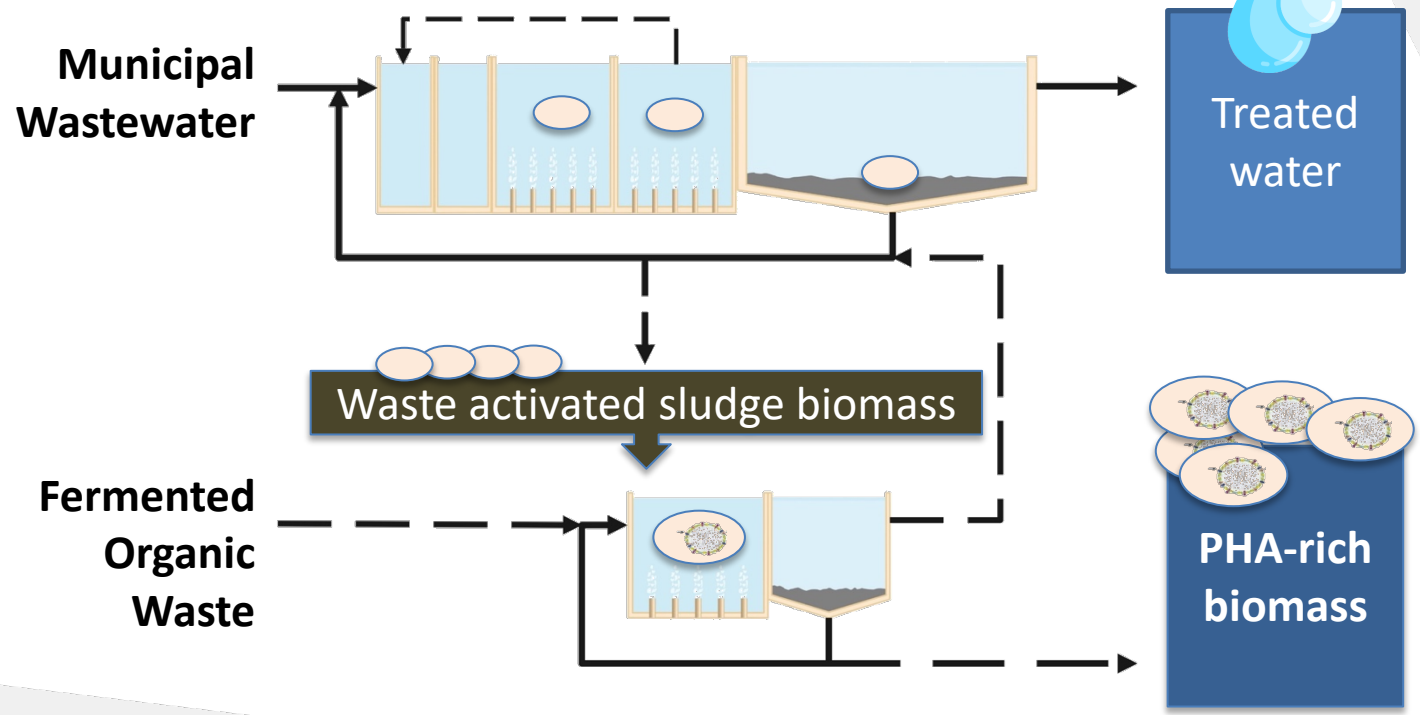
- Motivating scaling up a “Waste to PHA” resource factory
- 3 Criteria for a ROBUST SUPPLY CHAIN!
    1. RELEVANT *QUANTITY (Material Supply)*
    2. CONTROLLED *QUALITY (Material Value)*
    3. REGULATED STANDARDS (*Health and Safety*)

Harvesting waste activated sludge - Quantity

Parallel objectives with parallel products – clean water & biopolymers – Future WWTPs

Municipal wastewater treatment

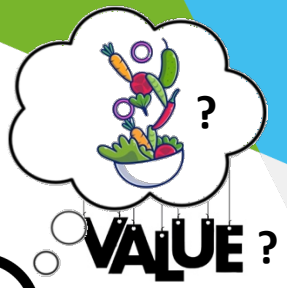
PHA-rich biomass production



Capacity to produce ≈15 000 tPHA/million person equivalent/year

Pei, Estevez-Alonso, et al. (2022). ES&T, *56*, 11729.
Estevez-Alonso, et al. (2022). Submitted manuscript.

Green solvent extraction process



Solvent Recycling

Solvent

PHA-rich Biomass

Heat & Time

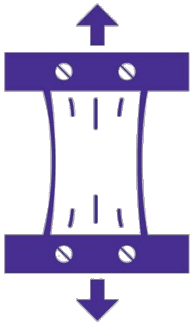
Filtration

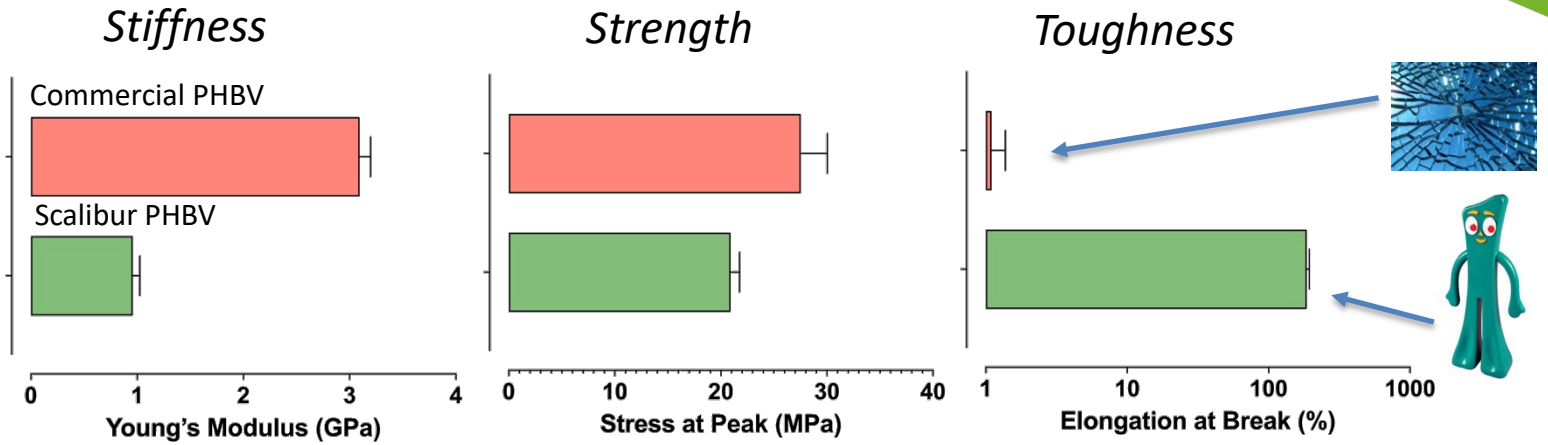
PHA Rich Solvent

PHA

Biomass Residual

Unique valued specifications - QUALITY





- Scalibur PHBV: good strength, excellent toughness
- Property specifications are unique
- Blending can compensate for lower stiffness
- First prototypes have been made by Itene

Food grade bioplastics from "waste".. 😕 ?

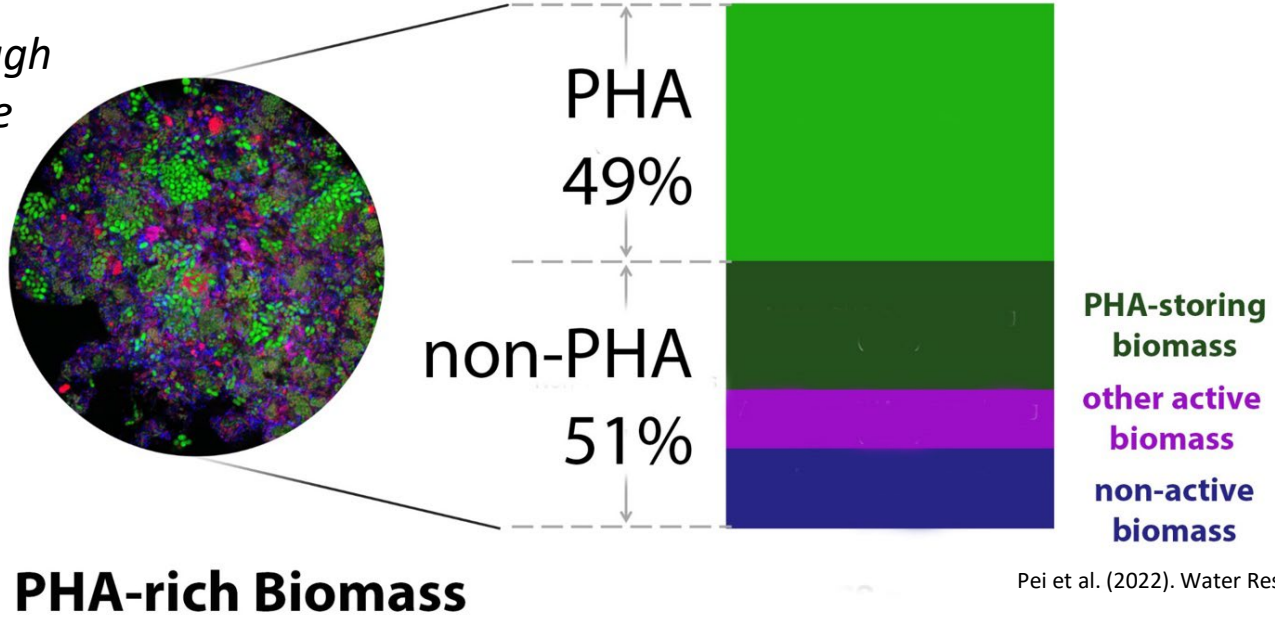
≈ 15 mL water/tablespoon

≈ 28 m^3 water can fill 1 shipping container

- It is not just the purity, but the ***type*** of minor impurities that have to be controlled
- Like less than 2 tablespoons of "*bad water*" in a container filled with "*good water*"

PHA extraction from dried PHA-rich biomass

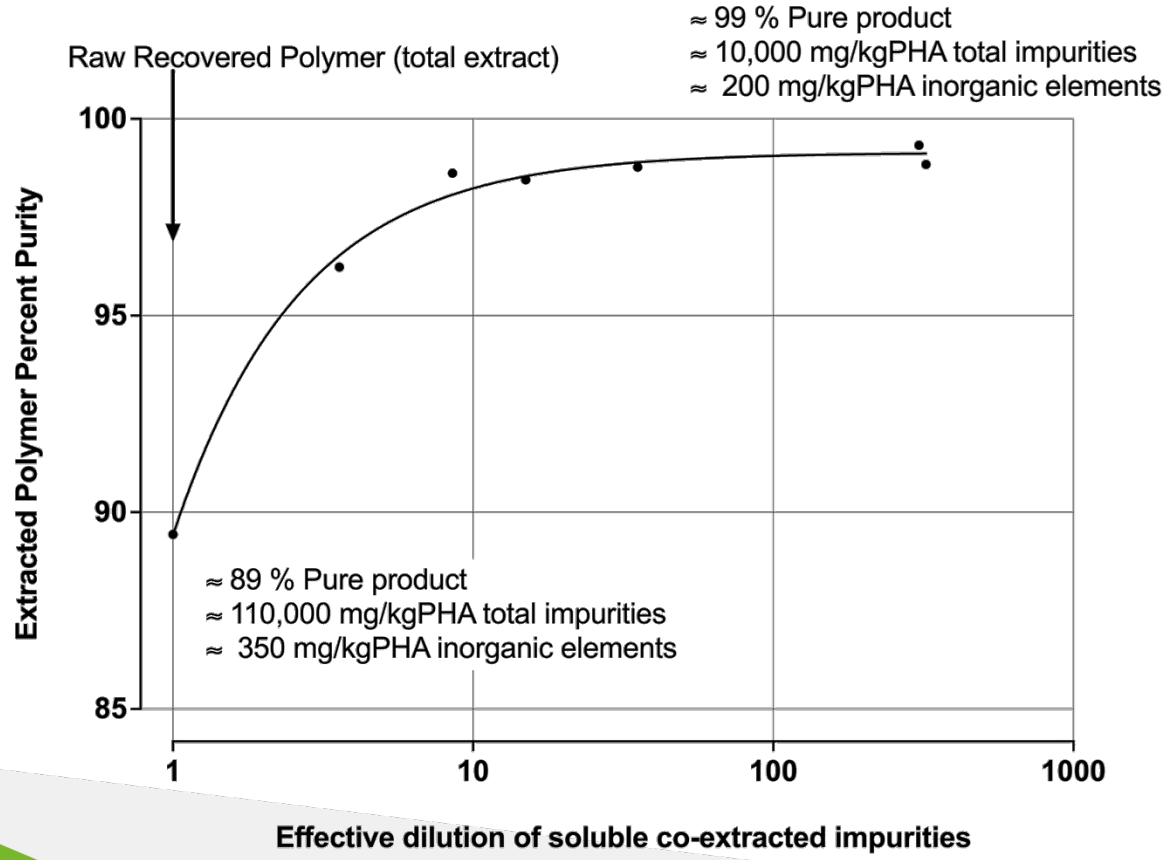
A view through a microscope



Pei et al. (2022). Water Research, 221.

≈ 100 % PHA dissolves in the extraction solvent
≈ 5 % non-PHA (organic and inorganic) also dissolves in the solvent
≈ 85 to 95 % total extract purity
Total extract purity depends on PHA content of the biomass

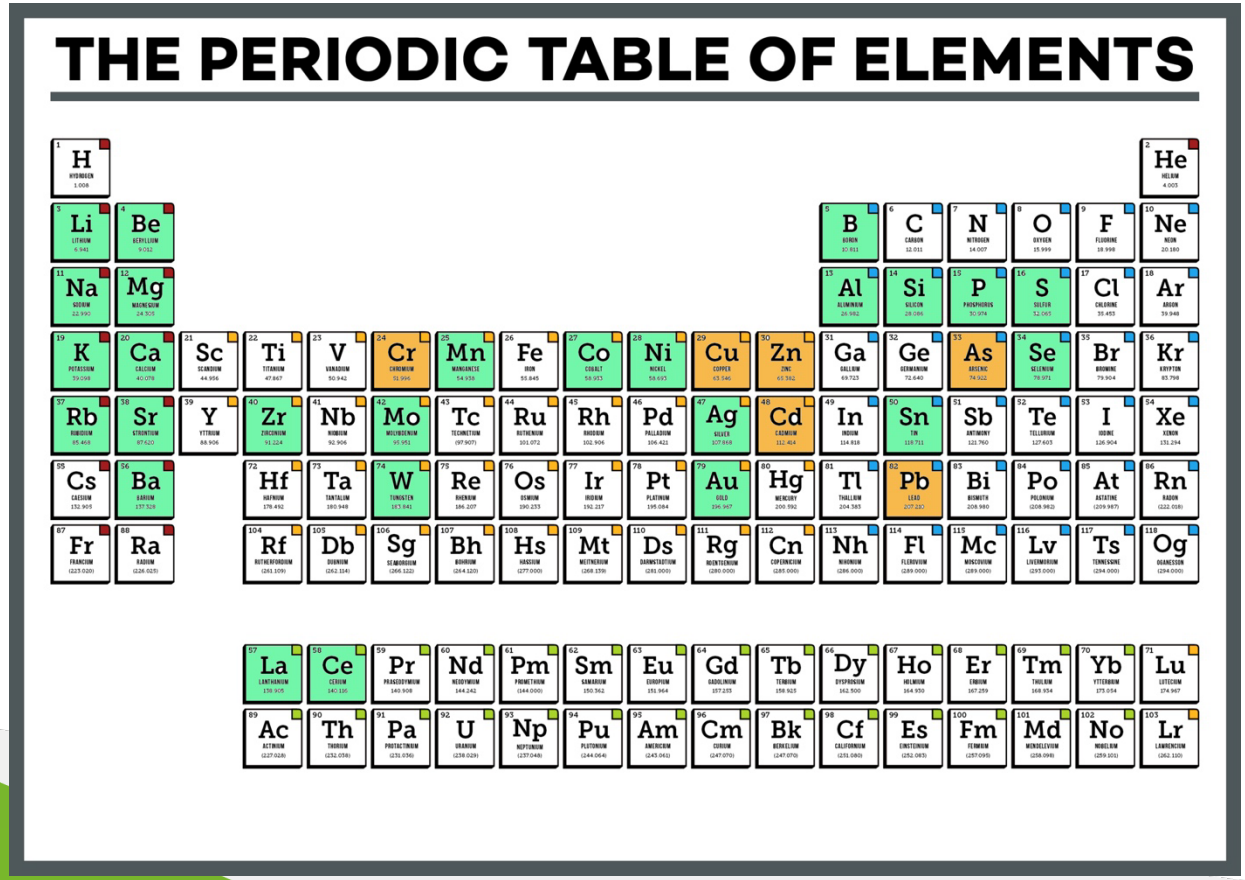
A high polymer purity can be readily achieved…



Almost all impurities stay dissolved in the solvent

… but need to consider the fate of specific inorganic and organic impurities ??

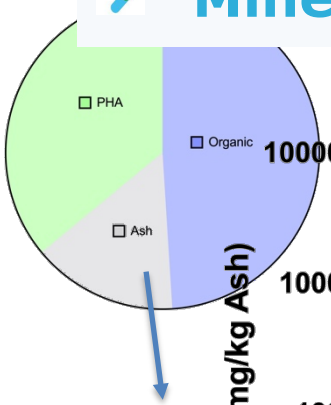
Scalibur - focus on fate of inorganic impurities

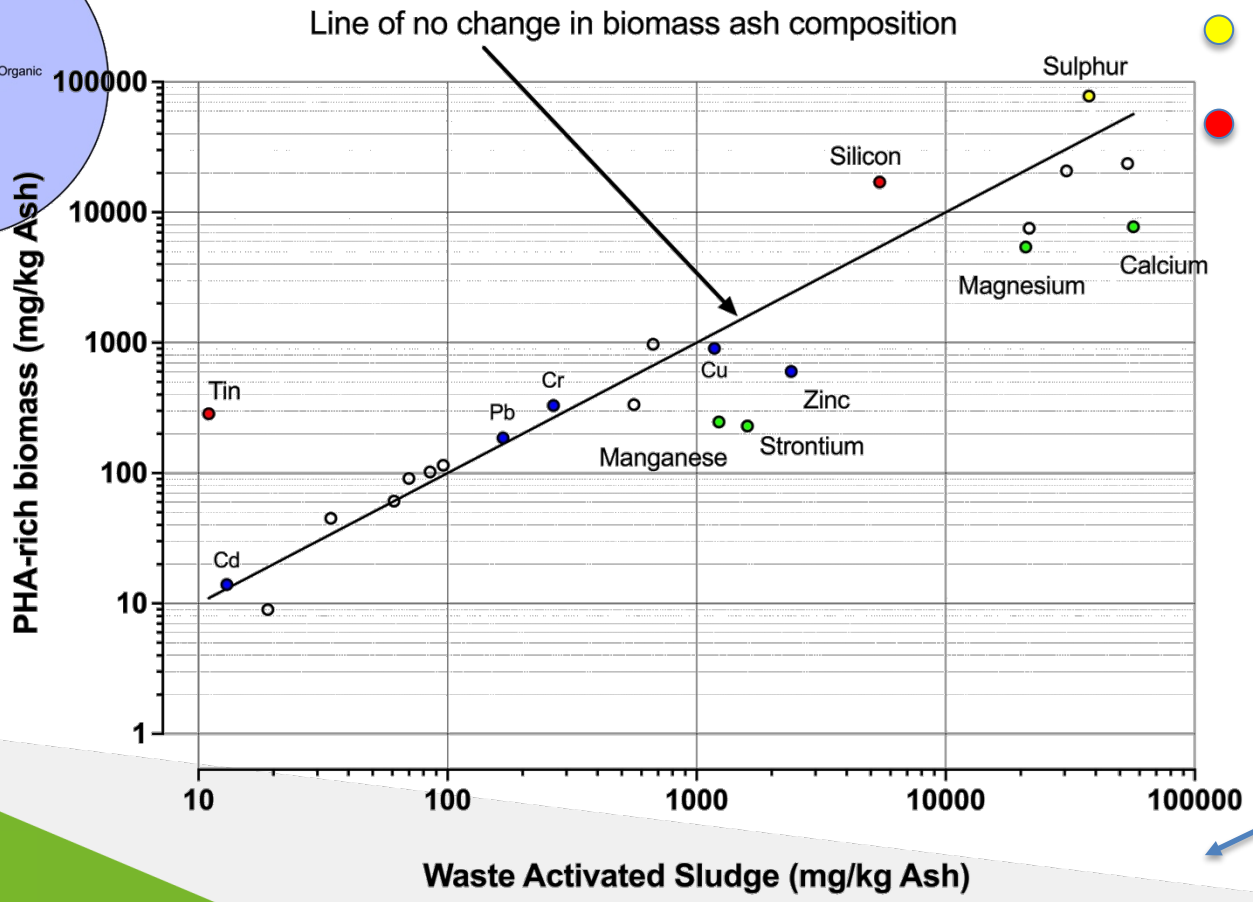


Regulated Limits;

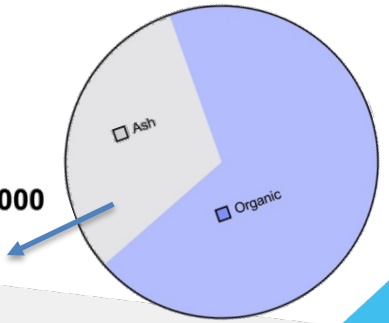
Cd and Zn < 100 mg/kg
Cu < 5 mg/kg
Cr, Pb, As < 1 mg/kg

Mineral content of raw vs. PHA-rich biomass "ash"

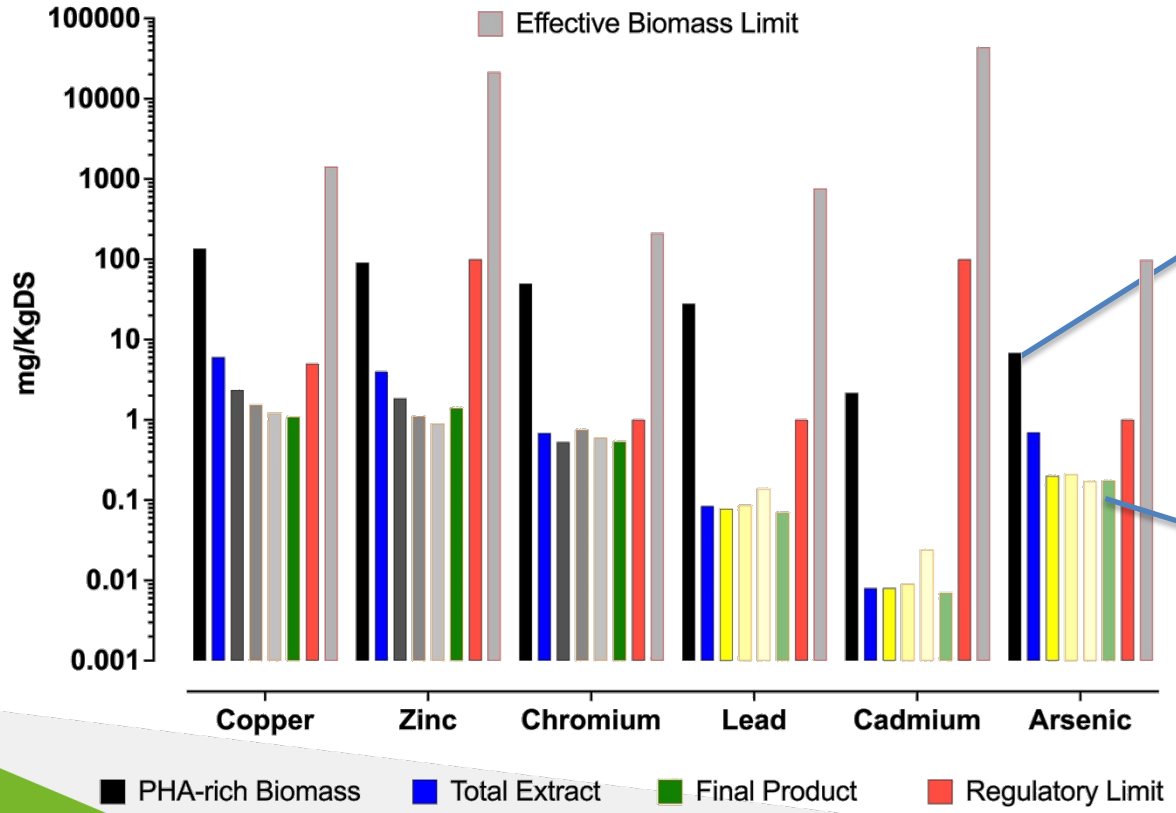




- H_2SO_4 acid addition
- Acid soluble elements from process equipment!

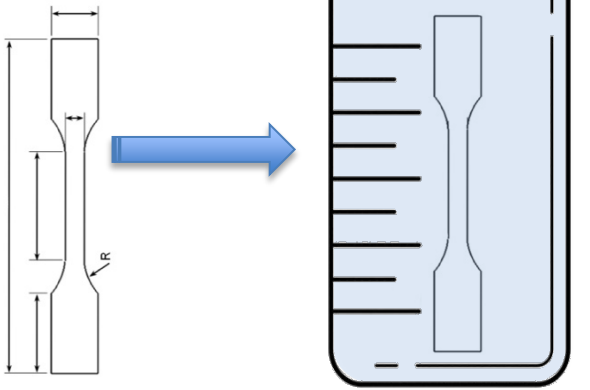


Mineral content fate over the extraction process



Focus on presence of (NIAS) organic impurities

- NIAS = *Non intentionally added substances*

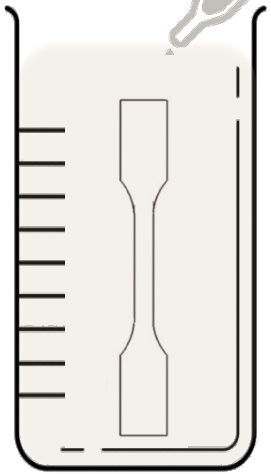


Injection molded test specimen

”food simulant” solution: e.g. ethanol, acetic acid,…

Incubation

Time & Temperature



NIAS migration to solution?

??

Pass ✓

✖ FAIL

”Failed” in NIAS migration limits trials… but

- Optimised process delivers uniquely higher molecular weight
- Process conditions can be tuned to remove residual organic matter
- Purity >≈ 99.5 % after selected removal of mobile organic impurities:
  1. Reduce colour development during extrusion (better quality)
  2. Meet regulations for NIAS migration limits (meet food grade regulations)
- Scalibur has taught us, made us think… and look to innovate process strategically
- Food contact quality is possible for plastics made from muncipal ”waste”

… opportunity for innovations are driven by initial failure!

Outcomes and outlook

- Muncipal wastewater can be applied to produce:
  - large ***QUANTITIES*** of PHAs
  - PHAs with unique commercially valued ***QUALITIES***
- Polymers of high purity can be recovered (>≈ 99 % pure)
- SCALIBUR PHBV polymers for food contact applications requires to:
  A. Select production process materials that do not leach unwanted metals
  B. Regulate metal content for PHA-rich biomass before extraction
  C. Remove selected trace residual *mobile* organic matter directly after extraction
- These "ABC's" are understood… and are now to be implemented in **scale up**

Scalibur research students hosted at Wetsus: Kevin Kim, Guilia Moretto, Ruqiya Nevoh, Fatma Sert, Gabriele Bontempi, Francisca Braga, Deimante Mis, Leonora Hibic Burtina, Michaela Majčinová, Wanda Placko, Pau Berenguer i Planas, Matteo Raspini, Bernhard Erlacher, Thomas van der Bent, Theo Rowden.

All Wetsus technical team, with special mention: Jelmer Dijkstra, Jan Tuinstra, John Ferwerda.

Wetsus theme members: Paques Biomaterials BV, N.V. Slibverwerking Noord-Brabant, STOWA, Unilever LTD.

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This project received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement Nº 817788