Rotary PRESIDENTIAL CONFERENCE ITALY

Economy and Environment in Harmony

Managing waste for a greener environment

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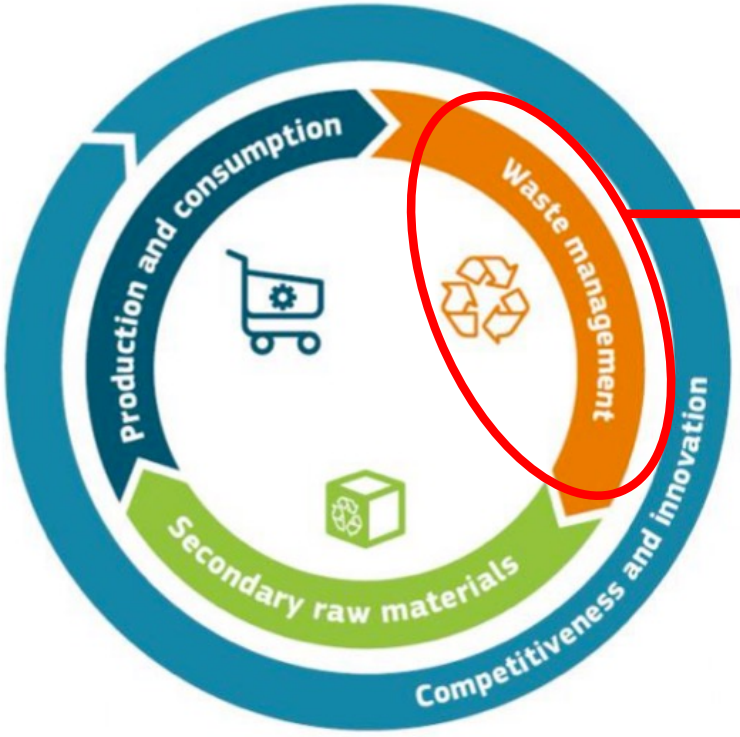
Circular economy: from waste to resource

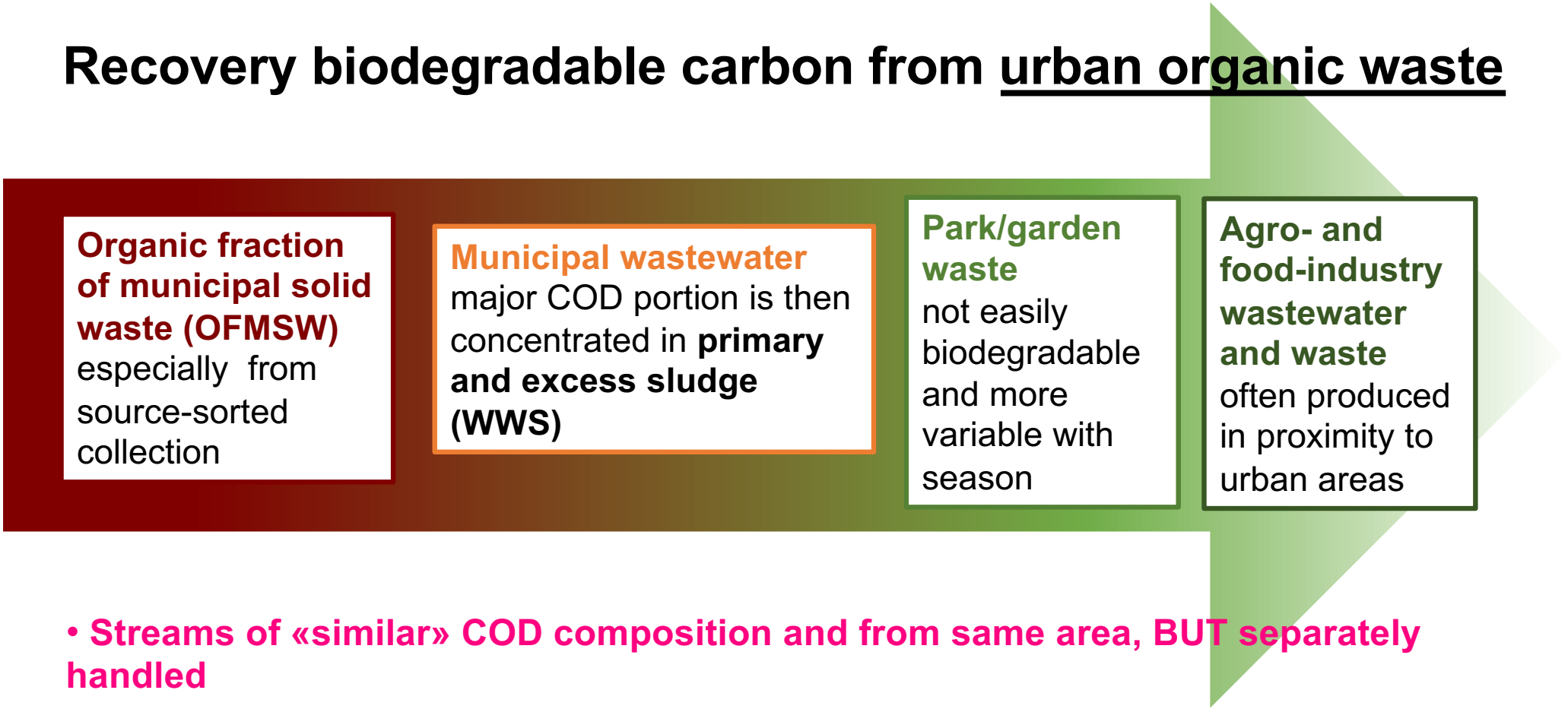
New Circular Economy Action Plan 2020 (EC)

- New focus on product design phase



- 2.5 billion tonnes of waste generated each year in EU (EPRS, 2016)
- **Problematic disposal for most of categories** (esp. Sewage sludge and organic fraction of municipal solid waste in urban areas)
- Waste framework directive 2008/98/EC (old)
- Few technologies to recover resources applied as **isolated systems**

Recovery biodegradable carbon from urban organic waste



- **Streams of «similar» COD composition and from same area, BUT separately handled**
  - ✓different collection systems, different technologies, separate regulations
- **COD is seldom recovered, but for**
  - ✓carbon stabilization as **compost** (soil improvers)
  - ✓energy recovery into **biogas**
- **Limitations**
  - ✓stringent regulation
  - ✓quality (depending on bio-waste collection/treatment)
  - ✓low economic value

Biorefineries: transforming treatment plants into resource recovery facilities

URBAN CONTEXT

SOURCE SORTED WASTE
= **RENEWABLE SOURCE OF CARBON**

MUNICIPAL Wastewater Treatment Plant (WWTP)

\+ ADDITIONAL TREATMENT STAGES

VIRGIN MATERIALS FROM RECOVERED RESOURCES

e.g. Biofuels, biopolymers, etc.

Biorefineries: transforming treatment plants into resource recovery facilities

URBAN CONTEXT

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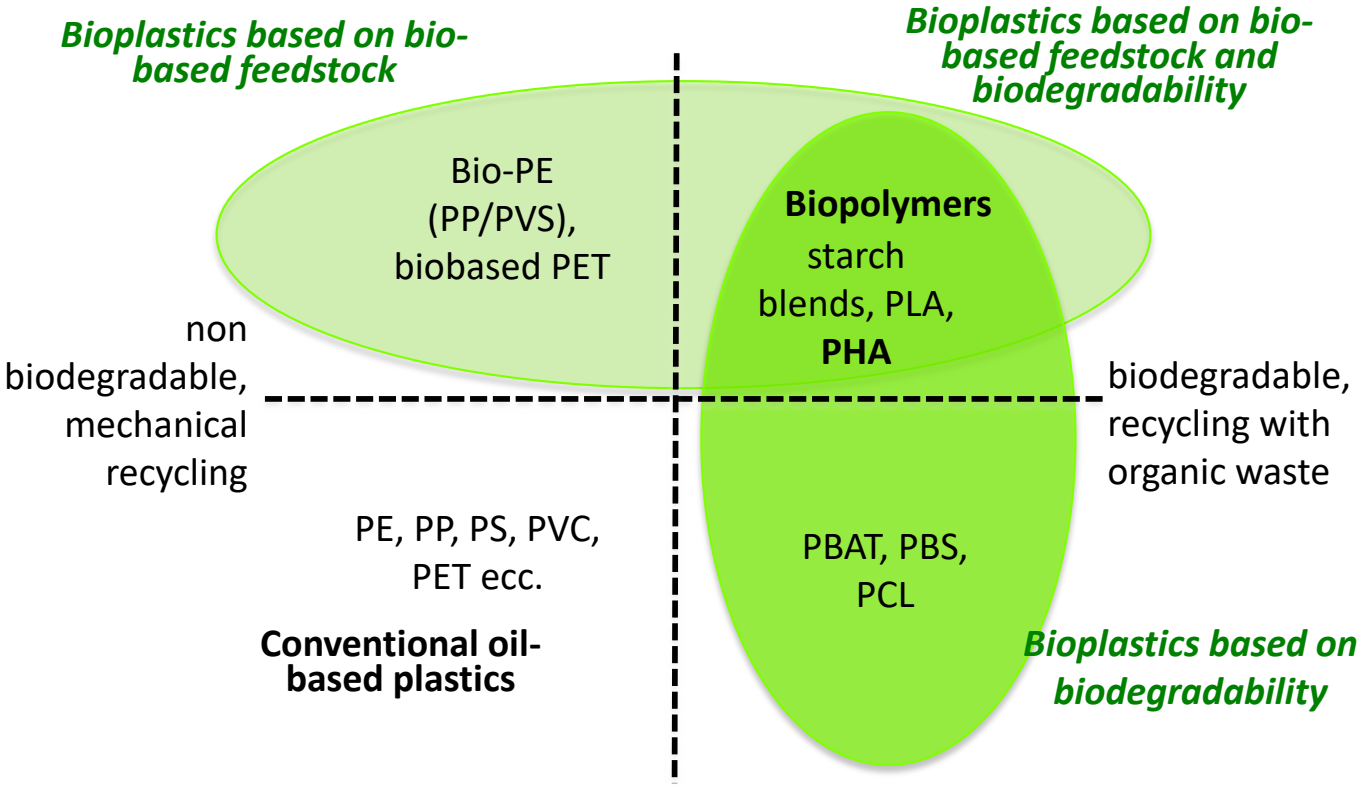
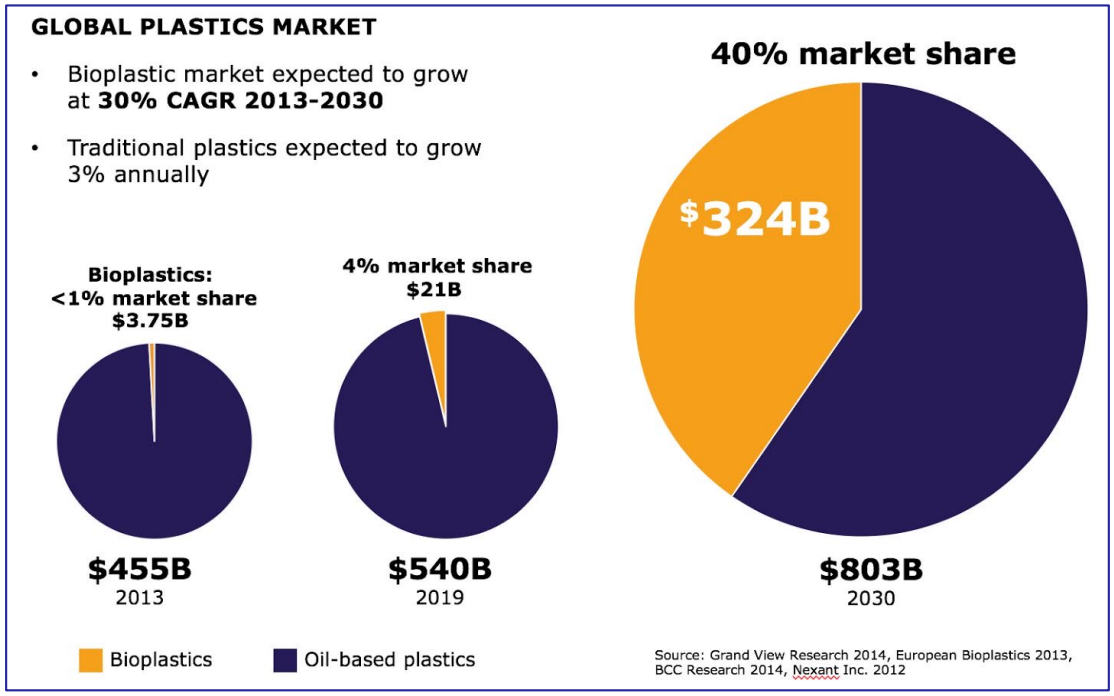
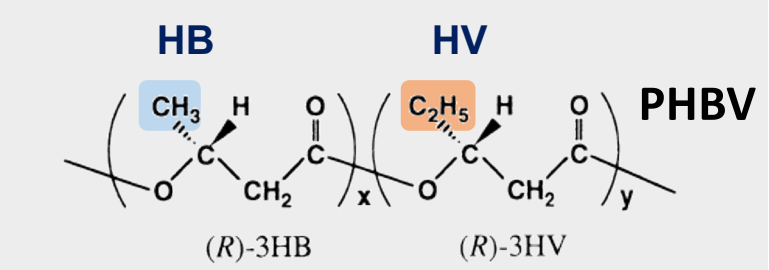
Bioplastics portfolio

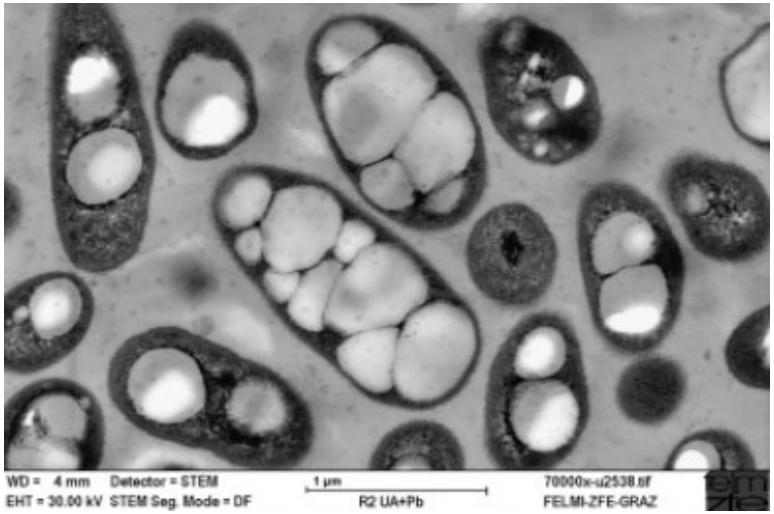




- ✓ The **European Strategy for Plastics** asks for decreasing dependency on oil-based plastics, increasing recycle
- ✓ **Bioplastic** market is still very less than oil-based plastics, but much faster growth is expected.

Why focusing on PHA?





Product related Pro's

Family of copolymers with tunable composition

PHA can be the main constituent of several bioplastics, with a wide portfolio of applications.

Portfolio

- Biodegradable commodity film
- Packaging interlayer film
- Specialty durables (such as electronics)

Production process Pro's

• A novel **open microbial cultures process** (not pure strains), to better cope with **large heterogeneity of the waste feedstock**;

• PHA production process is mostly **biological, under mild conditions and reliable**.

• Easier integration with existing biological plants for waste and wastewater treatment.

Appealing

- Produced from renewable feedstock (**no food**)
- Produced in biological process (**no OGM**)
- **Biodegradable**: not recycled but virgin material

Applications and economics

High market potential

As higher as more PHA cost decreases; but still higher value than biogas and compost

Under investigation at TRL 6

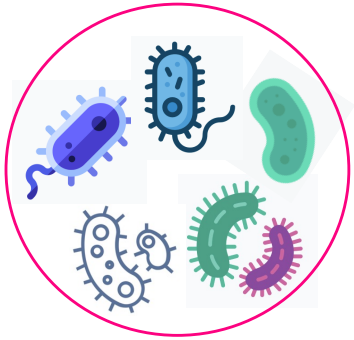
PHA production methods

Pure culture system (from ‘70s)

a) Refine feedstock
b) Sterilization
c) Low adaptation to waste treatment

Mixed Microbial Culture - MMC (from end of ‘90s)

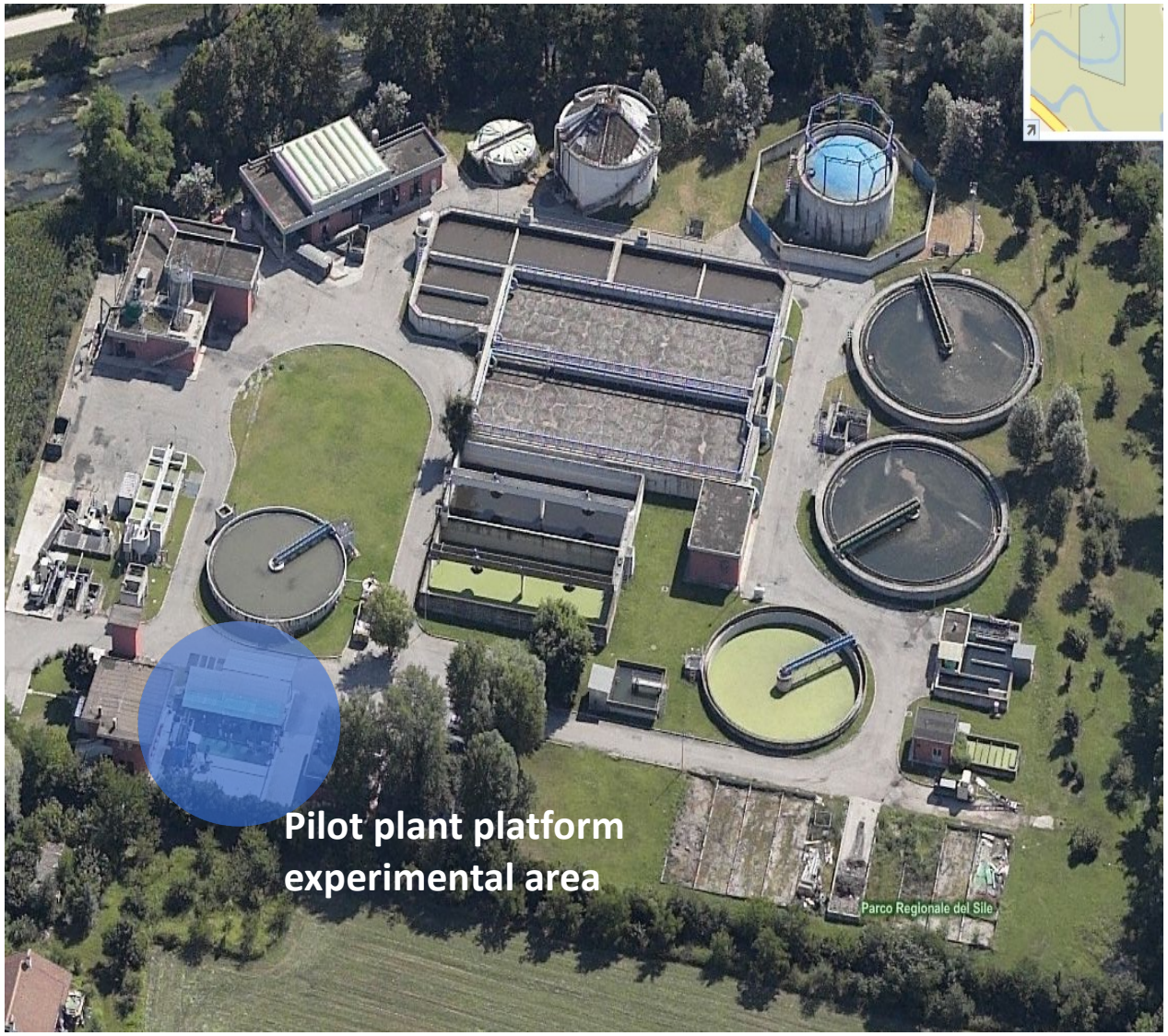
a) Waste feedstock
b) Robustness and adaptability
c) No sterilization
d) Integration in existing waste facilities



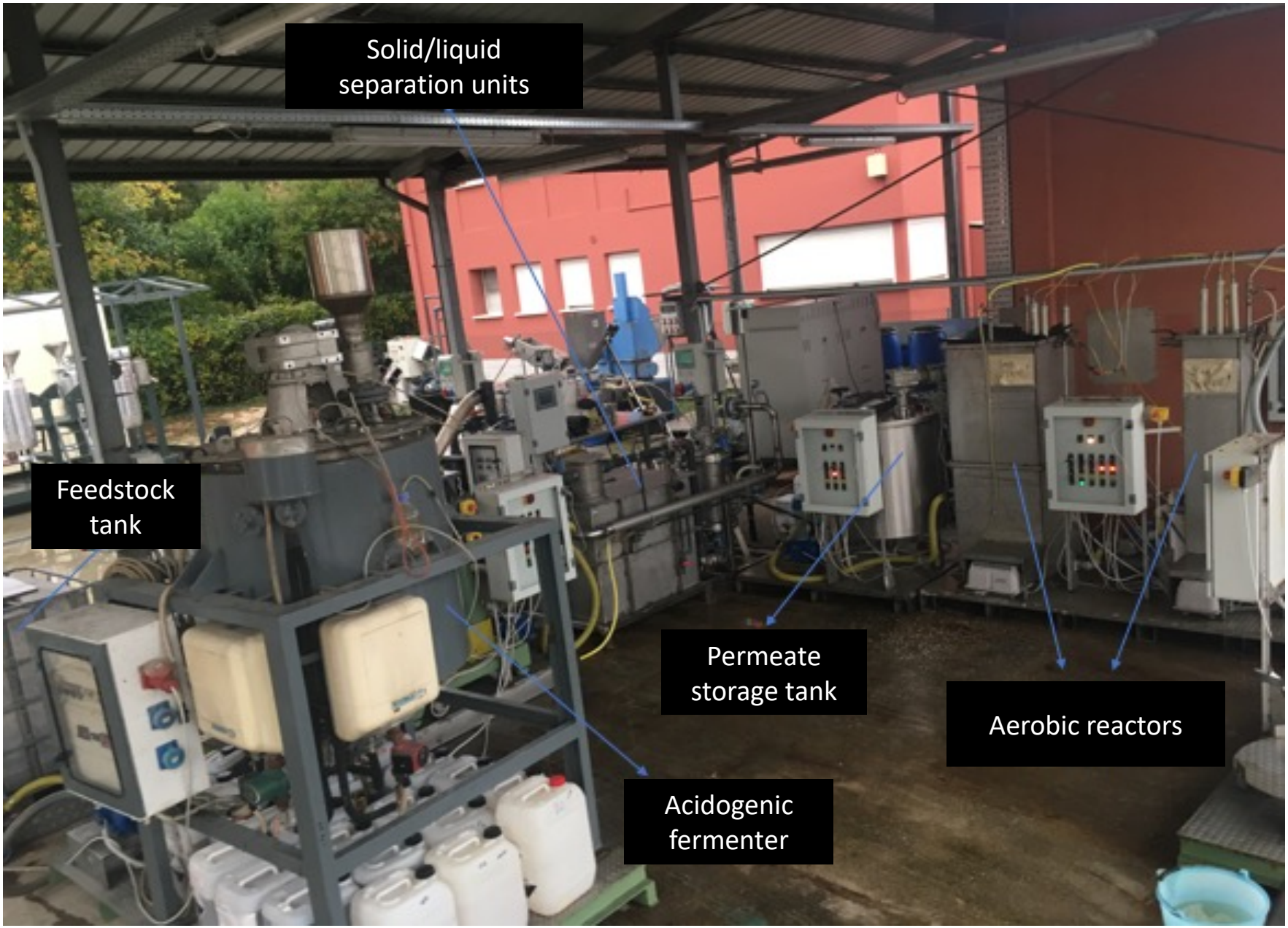
Treviso (TV) WWTP ATS S.r.l.

(Alto Trevigiano Servizi – North East Italy)

OFMSW-Sludge Anaerobic Co-digestion	
Feed characteristics	
Flow, m^3/d	10 biowaste + 100 sludge
TVS, %TS	70
Operational parameters	
OLR, $kgVS/m^3d$	1.5
HRT, d	20-24
Temperature, °C	35-37
Yields	
Biogas, Nm^3/d	950
Methane, %	60-66
SGP, Nm^3/kg VS (% biowaste)	0.43
TS removal, %	28
VS removal, %	39



Pilot Plant Biorefinery for PHA production



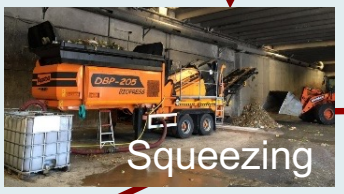
Flow-sheet of biopolymer production from urban biowaste (pilot scale plant in Treviso, Italy)

Feedstock (from industrial scale plants, on site)

Urban wastewater

sludge

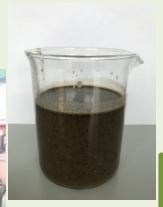
OFMSW



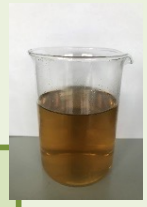
Solid phase to composting

slurry

Acidogenic fermentation (anaerobic)



Solid/Liquid separation



VFA

Solid phase to energy recovery

Upstream (on site)

air

Biomass production (aerobic SBR)

Process (on site)

air

Polymer production (aerobic batch)

Solid/liquid separation

liquid phase to energy recovery

Quenching

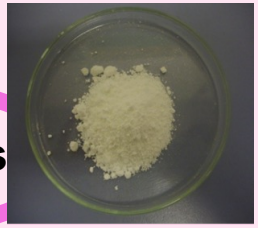
Polymer-rich biomass

Energy

Anaerobic digestion

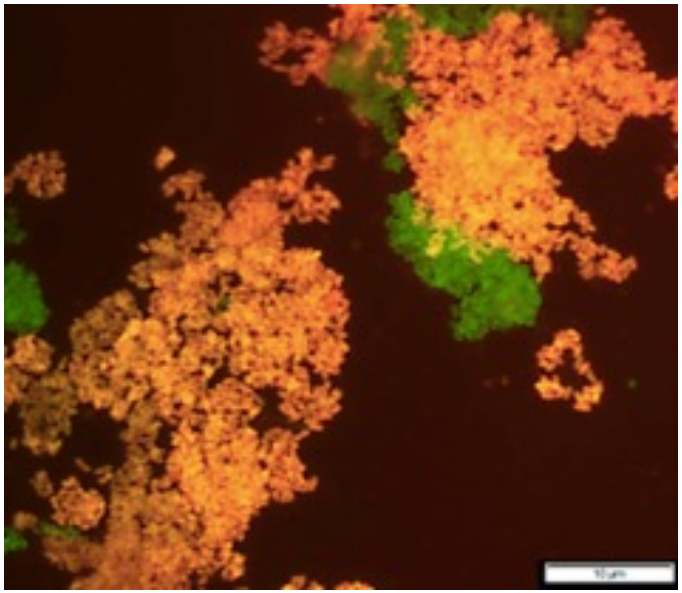
Extraction/ purification/ formulation

Bioplastics



Downstream (off-site)

Microbial Community (who is behind such efforts)



FISH image

green: Bacteria (EUB mix probe)

orange: *Hydrogenophaga* cells (HYD208 probe)

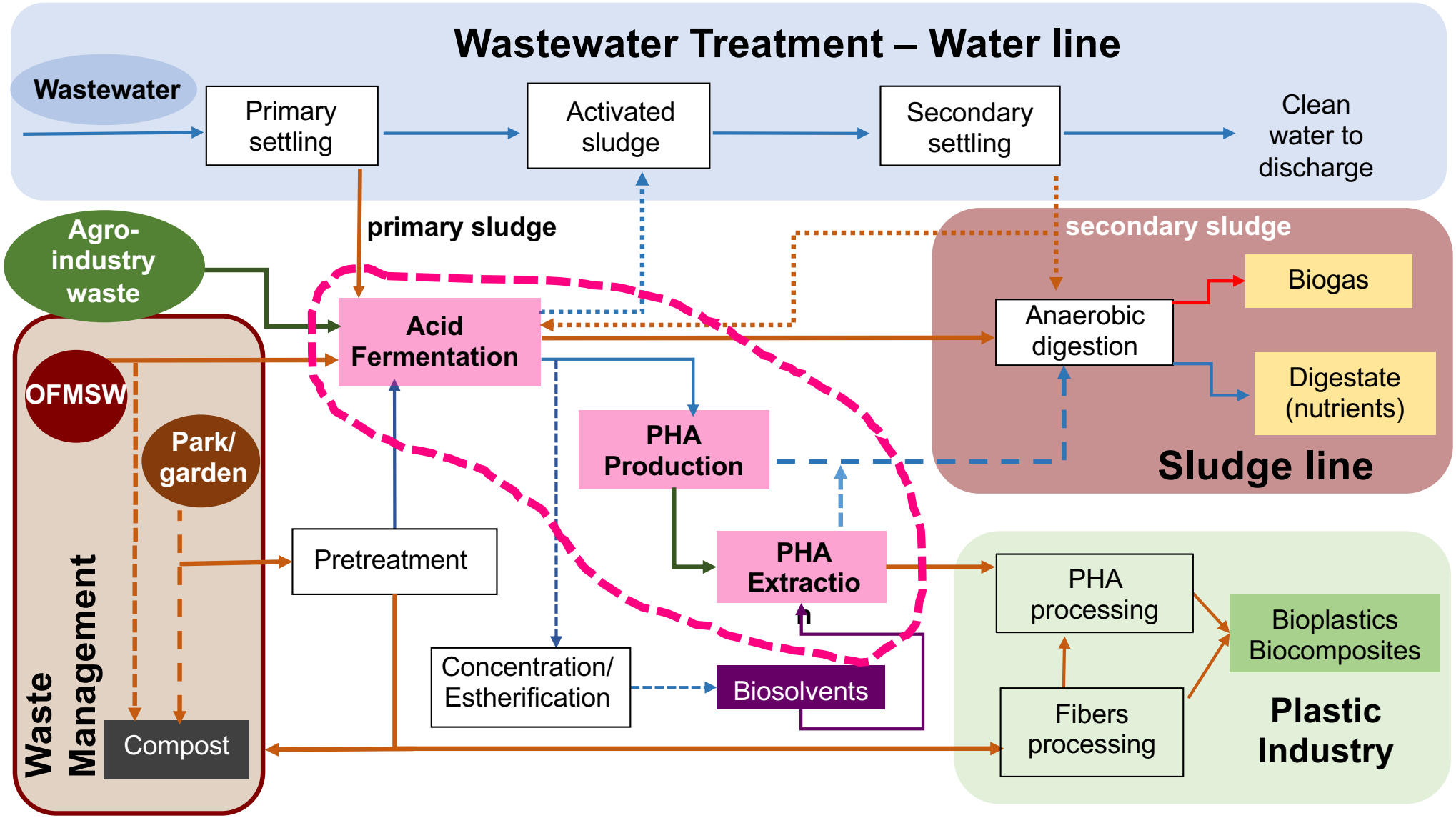
80% of total bacteria

Scale bar = 10 µm

Progress of waste transformation

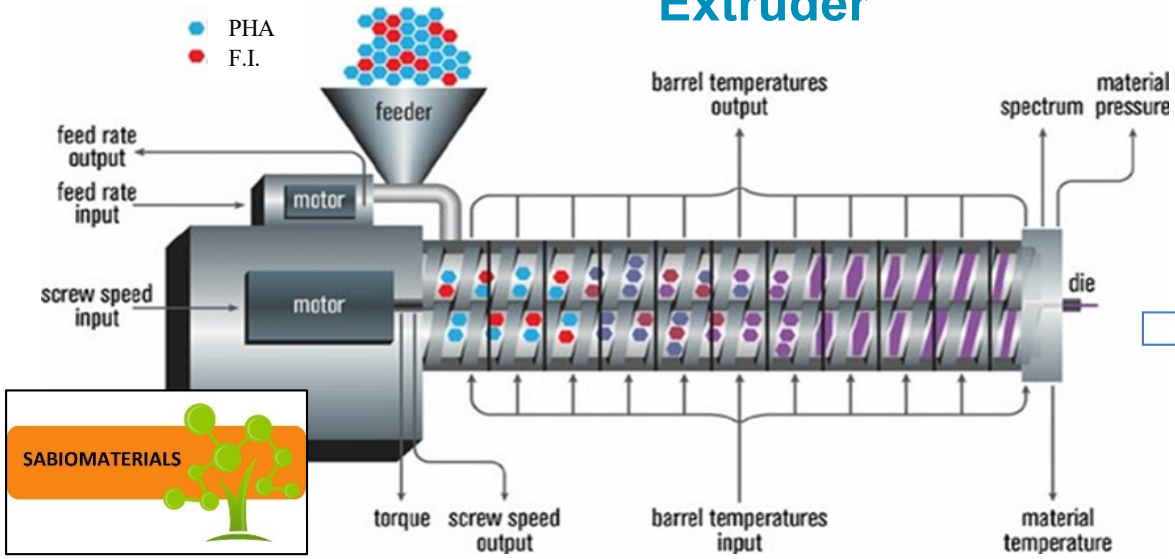
Food Waste	Sludge	Solid residues (to CH_4)	Liquid stream (to PHA)	Biomass slurry	Thickened (to PHA extraction)
Initial feedstock		**Feedstock after upstream processes**		**Feedstock before downstream processes**	

Linking the urban organic waste biorefinery with existing waste/wastewater treatment facilities and plastic industry



Main achievements (1)

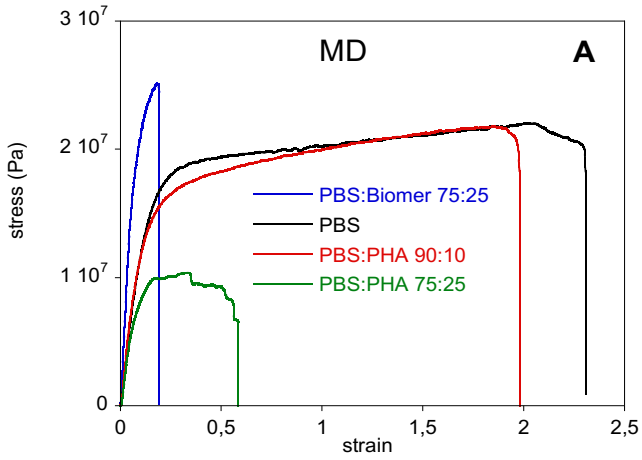
Extruder



PHA (granules)

Blow molding

Film



Machanical tests

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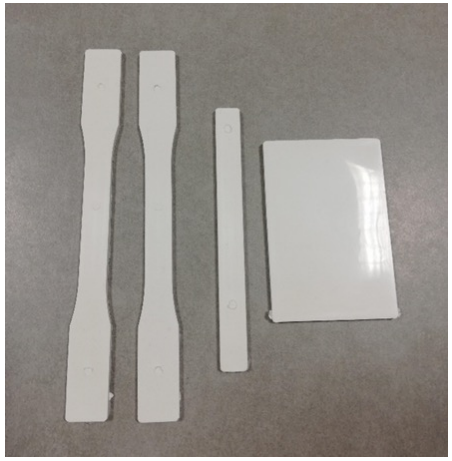
Main achievements (2)

PHA compound in pellet (**>90% PHA**)

Prototypes for mechanical tests

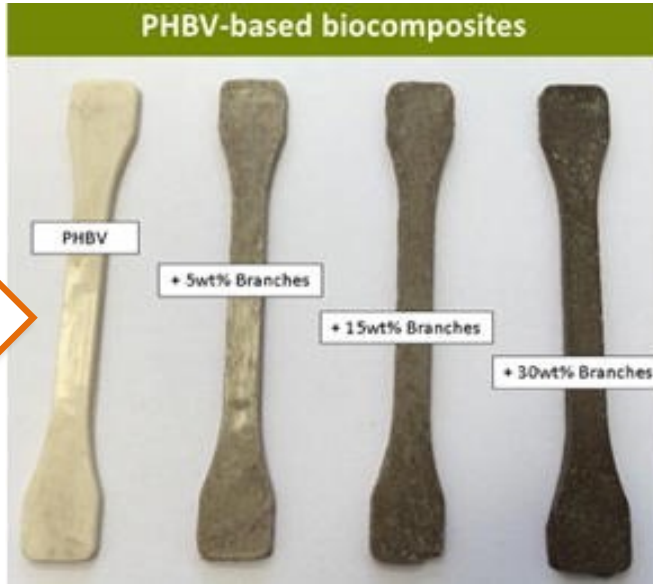


SABIOMATERIALS

Flexible handle

INRA SCIENCE & IMPACT

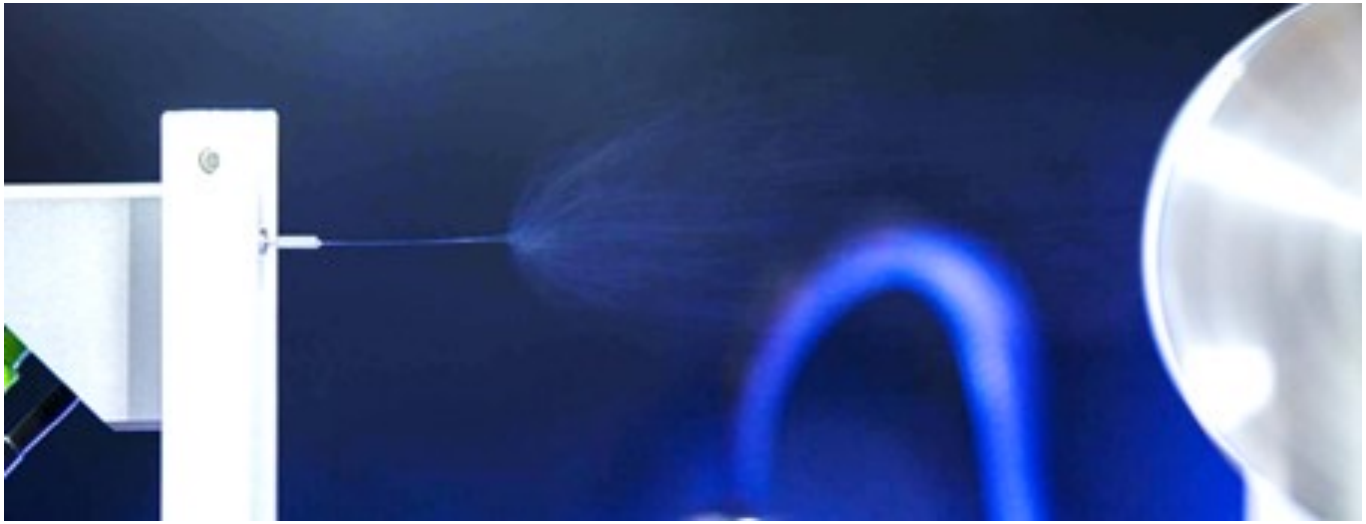
PHBV compounds with fibers collected from green biowastes



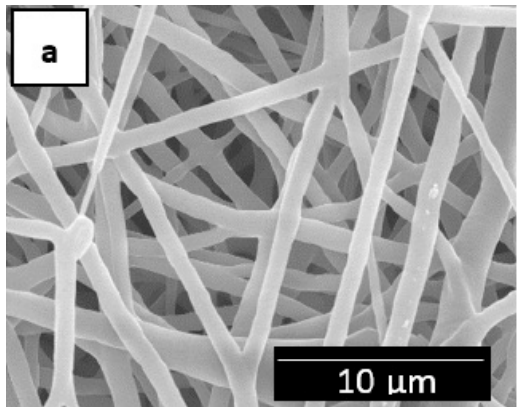
Viretto et al. Waste Management
https://doi.org/10.1016/j.wasman.2020.10.018

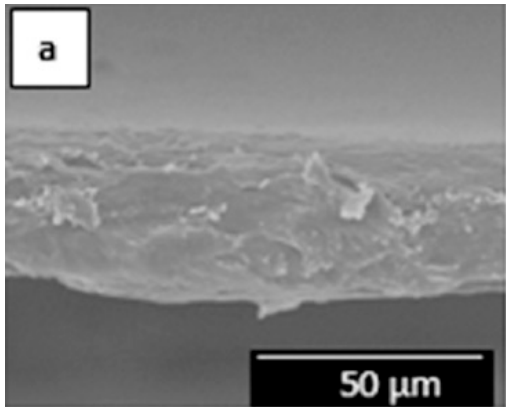
Main achievements (3)

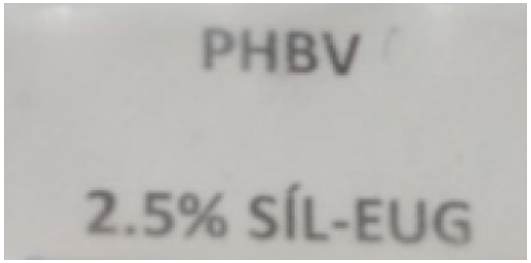
Electrospinning

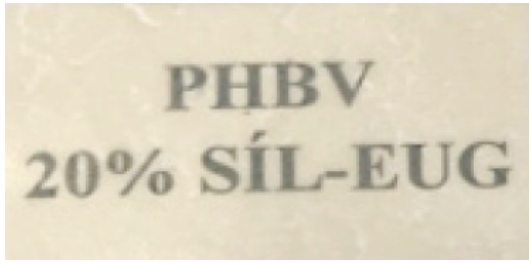


- Multi-layers film for permeability assessment
- Nanoparticles incorporation for properties improvement (active packaging, es. antimicrobial)
- Application as adhesive in substitution of fossil-origin products









Melendez-Rodriguez et al. Nanomaterials, https://doi.org/10.3390/nano9020227

EN Horizon 2020 Work Programme 2016 - 2017
17. Cross-cutting activities - Focus Areas

CIRC-05-2016: Unlocking the potential of urban organic waste
Research and Innovation Actions (RIA)

REsources from **UR**ban **BI**o-wa**S**te
RES URBIS
(in latin: things, goods, or affairs of the city)

3-year project, started January 1°, 2017
20 partners, 8 countries

Project coordinator: M. Majone
Research Centre for Protection of Environment and Cultural Heritage
University of Rome “La Sapienza”, Italy
Website: www.resurbis.eu

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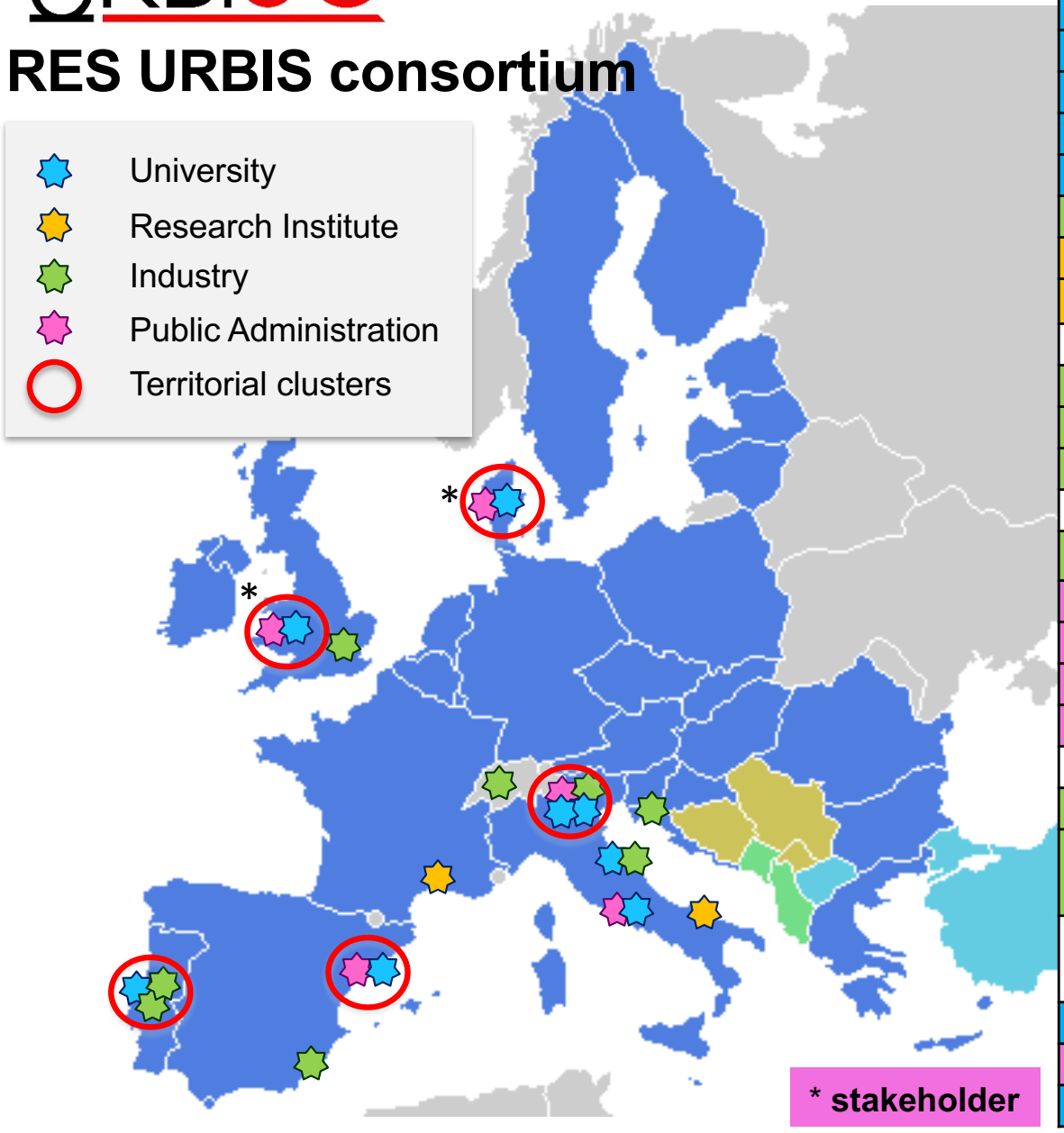
RES URBIS consortium



Process-related challenges
University of Roma “La Sapienza” (Italy)
New University of Lisbon (Portugal)
University Ca Foscari of Venice (Italy)
University of Barcelona (Spain)
University of South Wales (UK)
University of Bologna(Italy)
Biotrend (Portugal)
CNR – IRSA(Italy)
Inst. Nat. Recherche Agronomique (France)
Product-related challenges
BioInicia (Spain)
Mi-Plast (Croatia)
SABIO (Italy)
Territorial clustering
Aguas do Tejo Atlantico (Portugal)
Barcelona Metropolitan Area (Spain)
Province Autonoma di Trento(Italy)
Rhondda Cynon Taff County Council (UK) *
City of Copenaghen (Denmark)*
Economics and exploitation
InnoExc (Switzerland)
Bio-Based and Biodegradable Industries Association (UK)
Regulation, safety, environmental and social aspects
Technical University of Denmark (Denmark)
National Institute for work safety (Italy)
University of Verona (Italy)

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Venezia

Thank you!

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