



Development of innovative biotic symbiosis for plastic biodegradation and synthesis to solve their end of life challenges in the agriculture and food industries

# New bio-recycling routes for agrifood waste plastics

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*Workshop 2021 – Biobased materials research: Advances from ECOFUNCO and BIONTOP European projects – 16<sup>th</sup> June 2021*

# Outline

- The Project figures & the Consortium
- Agri-food Waste Plastics – A global concern
- RECOVER solutions and innovations
- Expected impacts
- Resulting products
- Synergies with BBI projects

# The project figures & the Consortium

**48 Months – Started 1st June 2020**

**17 Partners**

**7 Countries** (Belgium, Germany, Ireland, Italy, Portugal, Spain, United Kingdom)

**5.8 Million €** (ca. 4.4 M€ EC contribution)

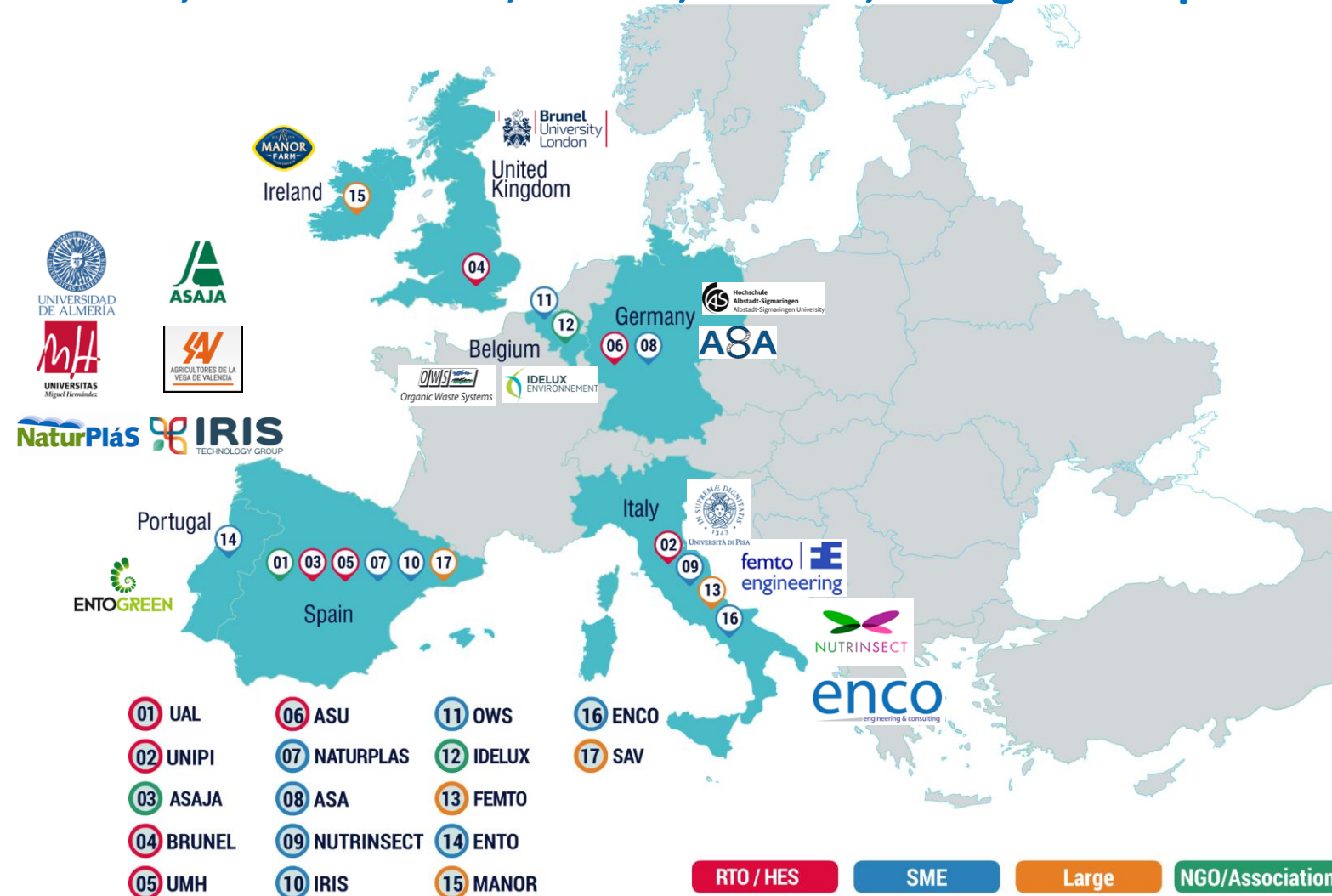
Call: **BBI-2019-SO2-R3** - Apply microorganisms and/or enzymes to resolve end-of-life issues of plastics

Enzymes + microorganisms + insects + earthworms  
Plastics for food packaging and agriculture

# The project figures & the Consortium

5 HES, 1 Association, 1 NGO, 7 SMEs, 3 large enterprises

Participant name	Short name
Universidad De Almería	UAL (Coo.)
Università Di Pisa	UNIPI
Asoc. Agraria Jóvenes Agricultores España	ASAJA
BRUNEL University	BRUNEL
Universidad Miguel Hernández De Elche	UMH
Albstadt-Sigmaringen University	ASU
NATURPLÁS PLÁSTICOS AGRICOLAS, S.L.	NATURPLAS
ASA SPEZIALENZYME GMBH	ASA
NUTRINSECT SRL	NUTRINSECT
IRIS Technology Solutions, S.L.	IRIS
Organic Waste Systems N.V	OWS
IDELUX Environnement	IDELUX
FEMTO ENGINEERING SRL	FEMTO
Ingredient Odyssey LDA - Entogreen	ENTO
CARTON BROS. - MANOR FARM	MANOR
ENCO ENGINEERING SRL	ENCO
S.A. Agricultores de la Vega de Valencia	SAV



# Agri-food Waste Plastics

Food packaging and Agriculture  
consume ~44% of worldwide  
production of plastics



End of life

Sorting



Management  
Systems

Waste

Plastics



Organic fraction +plastics



Released to the  
environment



31 % recycled



Non-recyclable:  
Mixed or  
multilaminated

Incinerated  
Landfiled

Compost  
contamination



Soil contamination

Polyethylenes (PE), Polystyrene  
(PS), Polyethyleneterephthalate (PET)

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New  **biorecycling routes**

Compost  
contamination



Soil contamination

 **Solution**

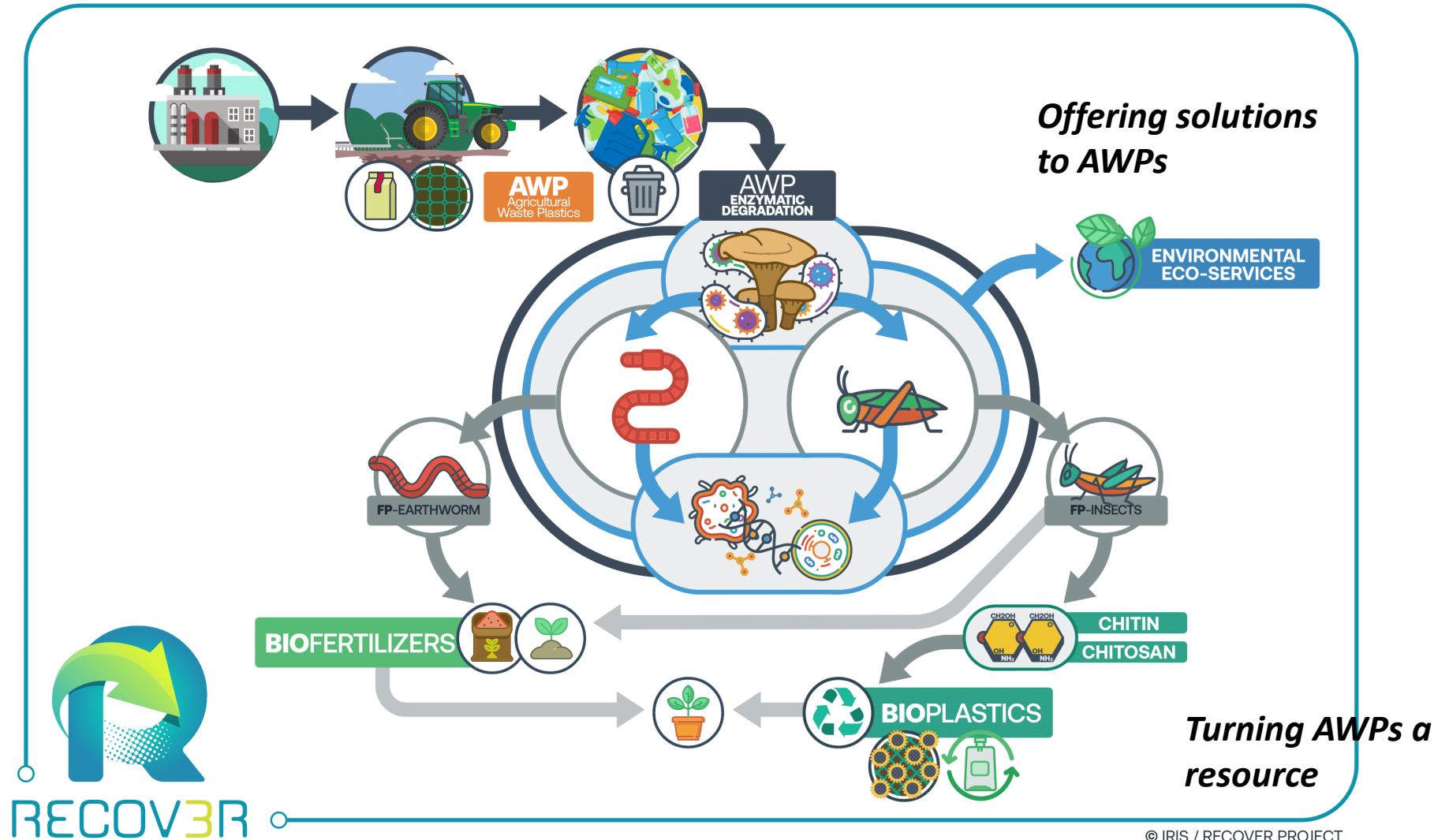
Polyethylenes (PE), Polystyrene (PS), Polyethyleneterephthalate (PET)

# Recover solutions & innovations

Agri-food Waste  
Plastics (AWPs)

Combining new  
enzymes,  
microorganisms,  
insects &  
earthworms

Products



© IRIS / RECOVER PROJECT

# Recover solutions & innovations

## Recover added value products and applications

Fraction	Product	Applications
Chitin from insect	<b>Chitin-based bioplastics</b>	Agriculture (pots, plant tips, etc)
		Food packaging
		Enhanced mulching films
Organic leftovers after chitin extraction	<b>Biofertilizer</b>	Agriculture
Vermicompost after plastic removal	<b>Improved Vermicompost</b>	Agriculture

# Recover solutions & innovations

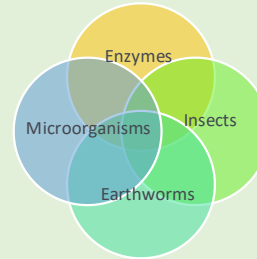


**Problem:** Quantify, characterize, define collection strategy, and pre-treatment

AWPs: Agricultural plastics in soils, non-recyclable food packaging plastics (MSW) and microplastics in compost



**Tool:** Select & upscale the production of **biotech** solutions



**Solution:** Upscale and monitor biodegradation capacities

In situ - Bioremediation: Soil  
Ex situ - Treatment: Compost & Vermicompost  
Insect rearing



**Value:** Develop added value downstream products

Improved biofertilizers  
Chitin-based bioplastics and coatings



**Sustainability:** Risks, safety, environmental impact, costs, logistic and cascade strategy

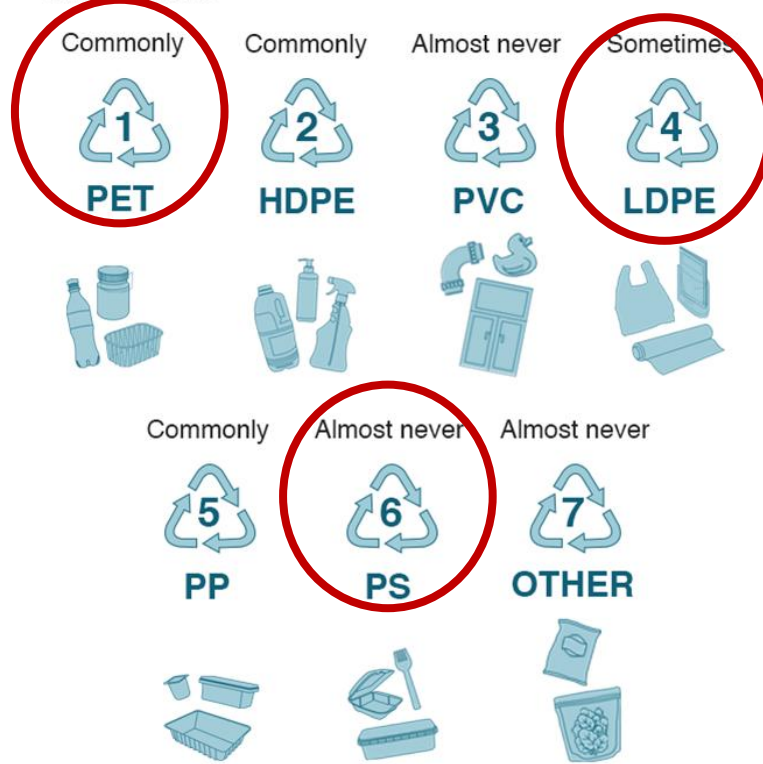
LCA & LCC & SLCA and C-foot print

Social, Scientific  
and Economical  
impact

# Recover solutions & innovations

**Problem:** Quantify, characterize, define collection strategy, and pre-treatment

Plastic packaging is made from seven different types and some are recycled more often than others



BBC



Food packaging, sweet and snack wrappers, hinged caps, microwave containers, pipes, automotive parts, bank notes, etc.



Reusable bags, trays and containers, agricultural film, food packaging film, etc.



Toys, milk bottles, shampoo bottles, pipes, houseware, etc.



Window frames, profiles, floor and wall covering, pipes, cable insulation, garden hoses, inflatable pools, etc.



Building insulation, pillows and mattresses, insulating foams for fridges, etc.



Bottles for water, soft drinks, juices, cleaners, etc.



Food packaging (dairy, fishery), building insulation, electrical & electronic equipment, inner liner for fridges, eyeglasses frames, etc.



**OTHERS**

Hub caps (ABS); optical fibres (PBT); eyeglasses lenses, roofing sheets (PC); touch screens (PMMA); cable coating in telecommunications (PTFE); and many others in aerospace, medical implants, surgical devices, membranes, valves & seals, protective coatings, etc.

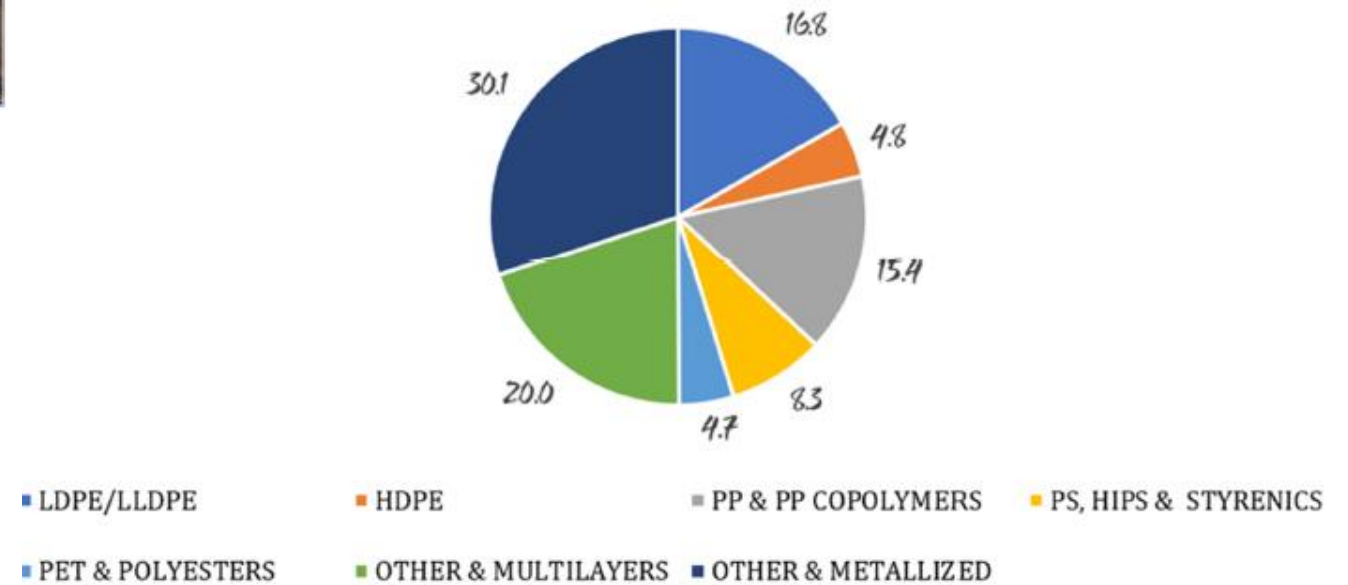
# Recover solutions & innovations

**Problem:** Quantify, characterize, define collection strategy, and pre-treatment

Collection and Analysis of plastic stream from food packaging and agriculture

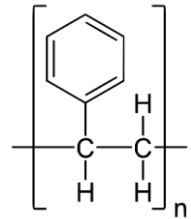


Percentages of analysed mixed plastics

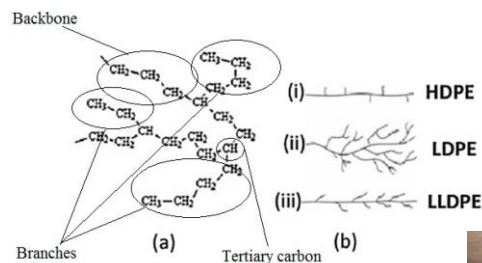


# Recover solutions & innovations

Tool: Select & upscale the production of biotech solutions



Polystyrene

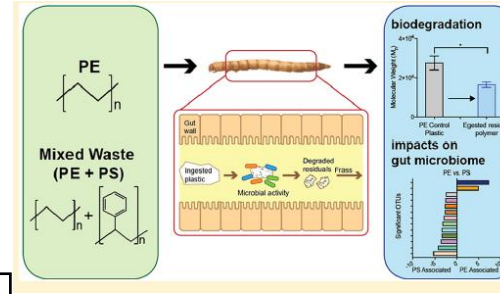
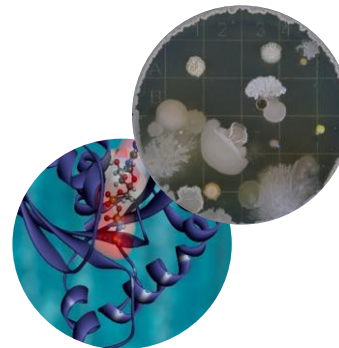


Polyethylene

Sen & Raut (2015) J. Environ. Chem. Eng., 3, 462–473



Yang et al. (2015). Environ Sci Technol, 49, 12080



Cassone et al. (2020). Proc. Royal Society B, 287.  
Brandon et al (2018). Environ. Sci Technol. 52, 6526



Earthworms & Insects (+microbiome)

Casts/faeces (microplastics)

Microorganisms (Lignin)

Enzymes (esterases, lipases, hydrolases)

$\text{CO}_2 + \text{H}_2\text{O}$

$\text{CO}_2$

Partial biode

AWP-adapted

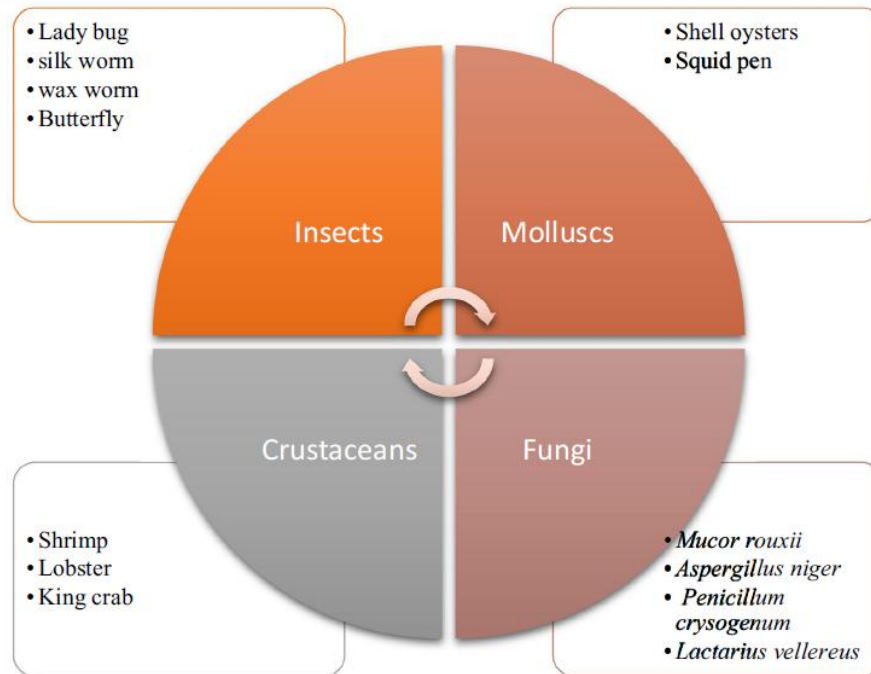
Consortia "ad hoc"

Enzymes "better than nature"

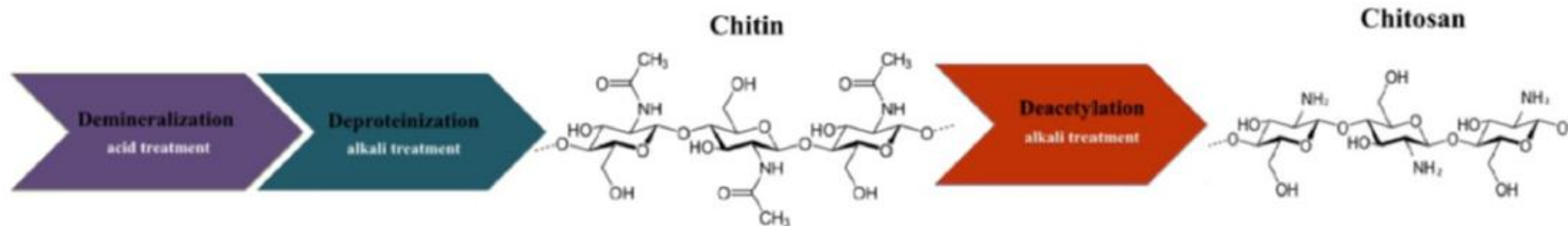


# Recover solutions & innovations

Value: Chitin from insects exoskeleton



**exoskeleton of arthropodes:** micro-composite of chitin fibrils in a protein matrix (containing also calcium carbonate)





Sustainable technologies for the production of biodegradable materials based on natural chitin-nanofibrils derived by waste of fish industry, to produce food grade packaging



## Production of films for shopping bags

*Blown film extrusion in industrial plant*

Good processability and tunability of thickness as a function of process parameters.



Recycled paperboard



Bio-blend + chitin nanofibrils + PLA/PBAT



Chitin on cellulosic substrates

Film produced by blown film extrusion in MICROTEC plant based on D material: the colour is slightly browner than the reference BIOCOMP BF 7210, but the transparency is similar.

**Anti microbial properties.**

# Expected impacts

*Offering solutions to the major problems posed by AWP*s

- Establish a **new circular cross-sectorial interconnection** (waste management & biotechnology) and **strengthen existing interconnections** (bioplastic/agriculture & agri-food).
- Create three **new bio-based value chains** (link standard plastics with insects/microorganisms and enzymes providers) and **remodel existing petrochemical-derived value chains** (biofertilizers, agricultural bio-films and food packaging)
- **Validate new and improved processing technology. Scale up approach.**



- **Reduce the generation and dispersion of microplastics and increase plastic recycling in EU by 12 %**
- Provide alternatives for the **removal of non-biodegradable plastics from the soil and the compost.**
- Contribute to **‘close the loop’ within the agricultural and packaging sectors** by converting AWP into biofertilizers and bioplastics for agriculture and packaging applications
- **Avoid around 80% of CO<sub>2</sub> emissions** caused by common incineration of plastic.



# Resulting products

- **Waste management**
- **Biotechnology industry**
- **Plastic converters**
- **Fertilisers**
- **Mulching films**
- **Food packaging**

## Processes

- Processes for **AWP biodegradation in soil and compost**
- RECOVER cascade process for safe and sustainable **AWP processing**
- Novel **method for chitin extraction**

## Products

- **Microorganisms, novel enzymes, and fortified insects and earthworms** for AWP biodegradation
- **Biofertilizers** based on vermi-compost, insect manure and/or chitin
- **Chitin-based bioplastics** for **agriculture** (pots, mulching films) and **food packaging** (trays, rigid containers, films) applications

# Synergies with BBI projects

- Microbial enzymes for treatment of non-recycled plastic fractions
- Apply ligninases to resolve end-of-life issues of thermoset composite plastics.



# Thanks for your attention!

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**@RecoverBBI**  
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WORKSHOP  
2021  
BIOBASED MATERIALS RESEARCH:  
ADVANCES FROM ECOFUNCO AND  
BIONTOP EUROPEAN PROJECTS

**ecofunco** **biontop**