A New of Wave of Industrialization*

in bio-based and biodegradable materials (BBMs)

2ND EMPHATI CONFERENCE| October 22, 2024| Bad Laer, Germany

Anindya Mukherjee, Co-Founder and Executive Board Member

Learn more!

*A New Wave of Industrialization of PHA Biopolyesters; Koller, M. and Mukherjee, A.; Bioengineering 2022, 9, 74.; https://doi.org/10.3390/bioengineering9020074

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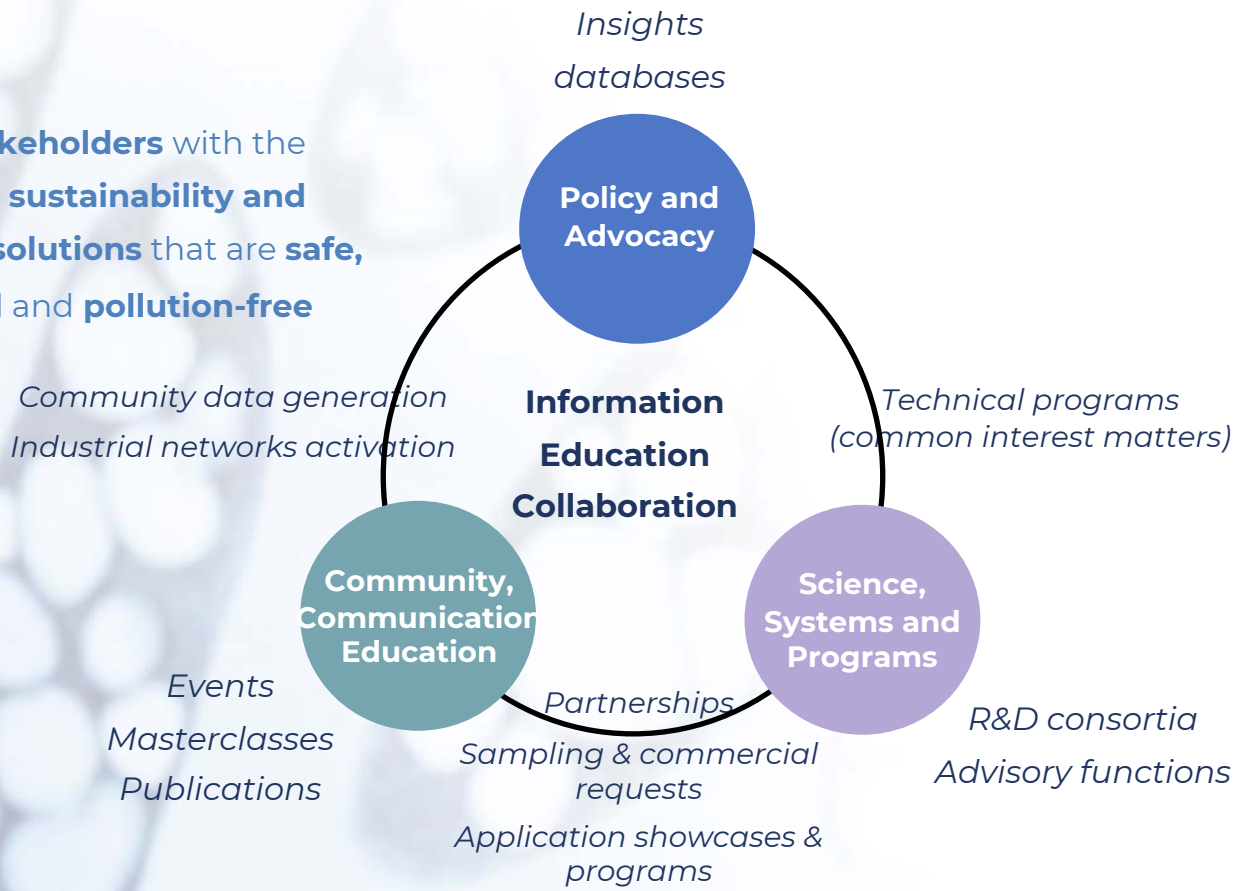
Who we are

A global coalition of **stakeholders** with the **Mission** to help achieve **sustainability and circularity** using **material solutions** that are **safe, environmentally sound** and **pollution-free**



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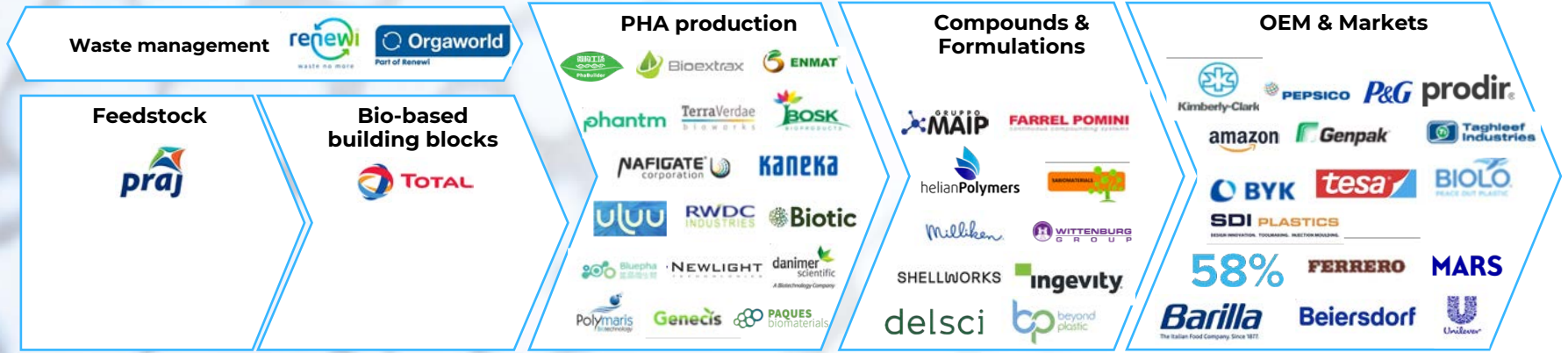
65 organizations share our mission



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BBM's (PHA Biopolymers) enable truly circular solutions*

Renewable, competitive, compatible with existing infrastructure, safe, and microplastics free

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Origin

Renewable carbon from the biosphere

Mimick nature's process in industrial scale

Functionality

Competitive in existing applications

Compatible with existing infrastructure

Impact

Built-in end of life options: Recycle, compost, biodegrade

Low to no environmental impact

Safety Biocompatibility

Benign to all life forms

Microplastics free

Learn more!

*Polyhydroxyalkanoate (PHA) Bio-polyesters –Circular Materials for Sustainable Development and Growth; Mukherjee, A. and Koller, M.; Chem. Biochem. Eng. Q., 36 (4) 273–293 (2022); https://doi.org/10.15255/CABEQ.2022.2124

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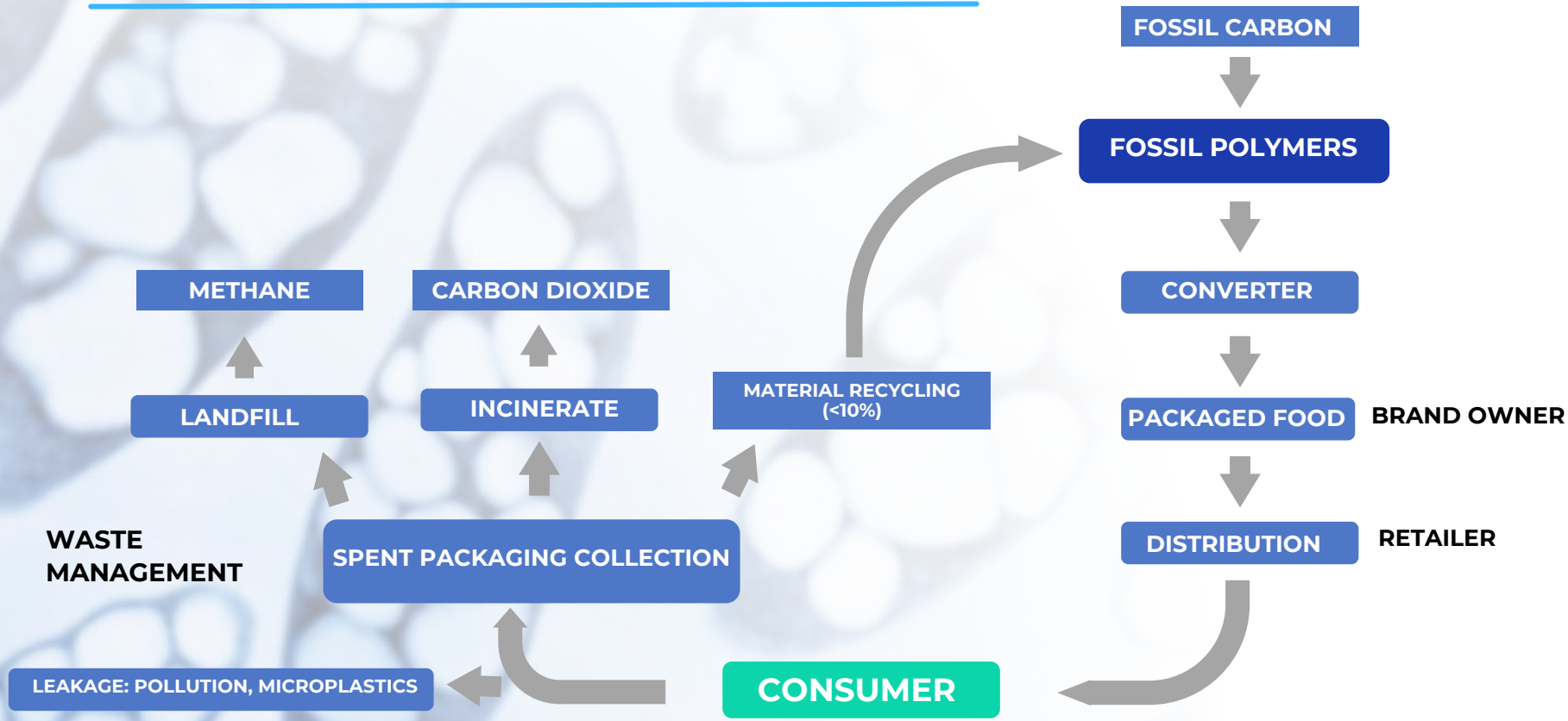
The Fossil Materials Value Chain



Is linear and creates pollution at every step

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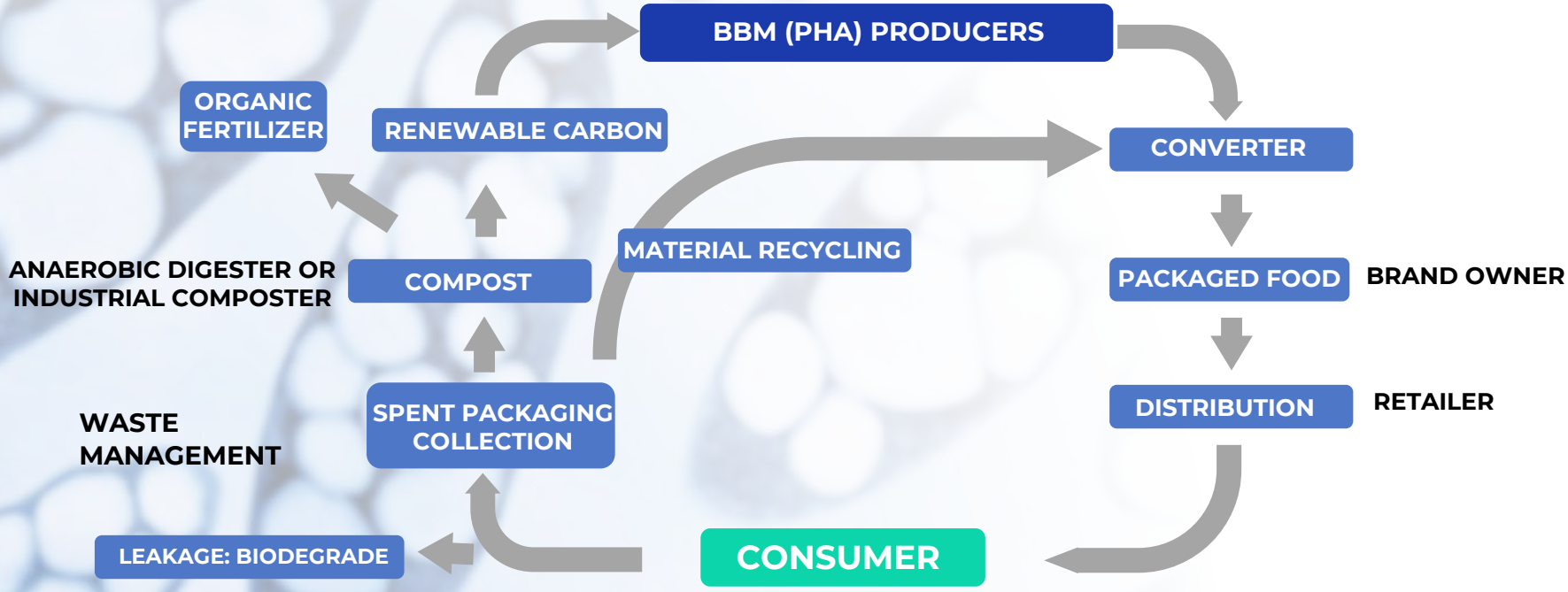
BBM (PHA) Value Chain



Regenerative - Renewable, Functional and Circular

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Design for Circularity Takes on Many Forms

Single use and durable applications

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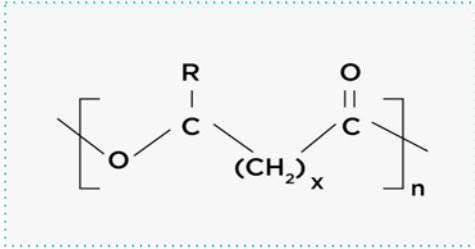
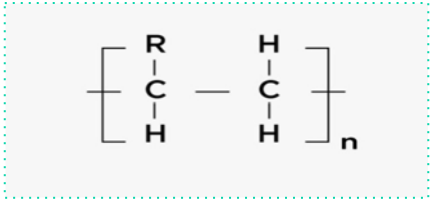
GO!PHA — Application Showcase

What are *Poly**H**ydroxy**A**lkanoates (PHA)*

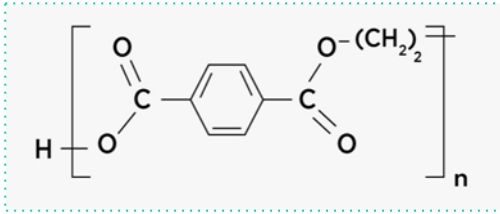
- **PHA is a family of naturally occurring biopolyesters**
  - Biosynthesized (and biodegraded) by an estimated 40% of microorganisms
  - **~150 different monomers** can combine for limitless functionality
  - ~10 of them have been evaluated, and 4 types are commercially available
- **PHA: Known for > 100 years, validated for > 40 years**
  - Discovered in 1888 by MW Beijerinck characterized in 1920's by Maurice Lemoigne
  - Gained notoriety in the 1970's when when its properties were elucidated
- **Poised to become the material of choice**
  - 32+ companies and several academic groups working on PHA
  - Renewability, functionality and multiple End-Of-Life attributes – **Recycle, Compost, and marine, freshwater and soil biodegradable if leaked**



PHA



R = H => Polyethylene
R = CH_3 => Polypropylene



PET

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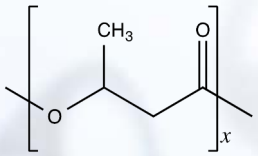
How does PHA compare to fossil polymers?

Similarities

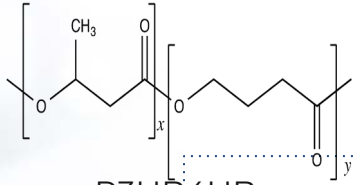
- thermoplastic and/or elastomeric
- Process like plastics
- barrier properties - gases, water, and oils
- Mechanical properties of PE, PET, PS, ABS, TPU

Differences

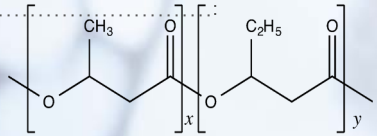
- Renewable
- Soil, freshwater and Marine Biodegradable
- Home and Industrially compostable
- non-toxic and benign



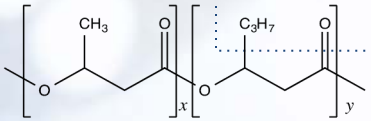
P3HB



P3HB4HB



P3HBV



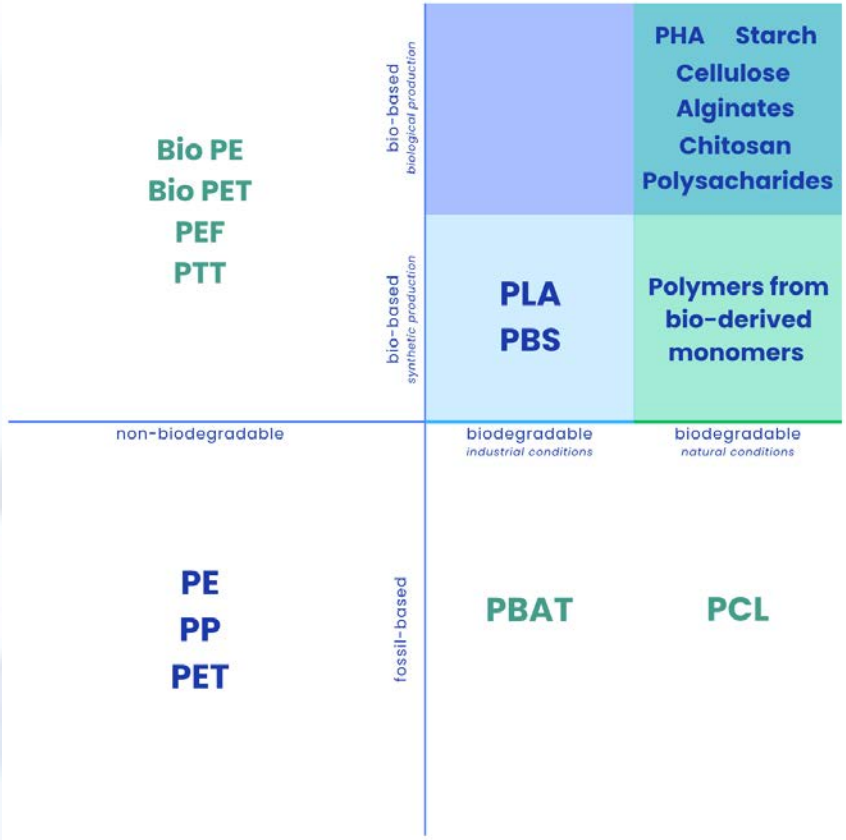
P3HBH

Composting and Biodegradation-nuances

The Four Quadrants differentiating Plastics and Suitable Substitutes

- Biodegradation mechanics and rates vary between product forms
- Factors include:
  - Material type
  - Product dimensions
  - Environment - soil versus ocean, ambient temperature

Learn more



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Policy & Advocacy

Create favorable regulations through proactive monitoring and influencing policy

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Policy & Advocacy – 2

Single Use Plastics (SUP) Bans

- **EU** (directive): PHA classified as plastic for the use in 10 product categories. Single-use plastic plates, cutlery, straws, balloon sticks and cotton buds cups, food and beverage containers made of expanded polystyrene, and all products made of oxo-degradable plastic
- **Italy** (decree) Article 5(3): exemption from the ban for single-use plastic products that are biodegradable or compostable and are listed in Part B of the Annex to the SUPD.
- **Japan:** As part of the SUP ban, business operators are required to switch to biodegradable plastic alternatives or pay surcharge on non-biodegradable products (EPR)
- **India:** Ban on single-use plastic excludes compostable materials, which are therefore allowed for making the specified banned products. The regulation does not define compostable or biodegradable plastics
- **California:** SB 54 and AB1201 - Focus on recycling

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Policy & Advocacy – 3

California

SB 54

- June 2022: California passes SB 54, a bill designed to curtail plastic pollution in the state.
- Establishment of a producer responsibility organization which must contribute $5bn over ten years to develop plastic end markets.
- Obligates plastic producers to hit source reduction targets, reducing overall waste.
- Draft regulations have been released, and are generally not positive for BBMS.

Opportunities

- Impact on a diverse global audience on the benefits and advantages of “substitutes and alternatives”

Challenges

- California requires NOP compliant materials, which PHA biopolymers are not.
- Composters will generally not accept BBMs, preventing integration into agribusiness.
- Failure to distinguish between fossil plastics and BBMs maligns innovative materials.

Impact

- California is a trendsetter in environmental policy, other states likely to follow suit.
- Possibility of BBMs being regulated out of the California market.
- Continued misunderstanding of core concepts transmitted to stakeholders

Read more on SB-54!

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Policy & Advocacy – 4

UN Treaty on Plastics

The Treaty

- March 2022: UNEA-5.2 adopts resolution for international legally binding instrument on plastic pollution.
- Establishment of Intergovernmental Negotiating Committee (INC) to develop "the instrument."
- Instrument to encompass full plastic life cycle: production, design, disposal.
- The deliberations revolve around a document outlining "Potential Obligations," with significant focus on exploring "sustainable alternatives and substitutes."

Opportunities

- Impact on a diverse global audience on the benefits and advantages of “substitutes and alternatives”

Challenges

- Lack of updated information and common knowledge of substitutes
- Country-specific infrastructure and capabilities to transition
- Green washing concerns
- Use of harmful additives with sustainable “alternatives”

Impact

- Countries and regions picking up on Treaty language and developments for local policy development
- Global recognition
- Research and development initiatives
- Growth and investment opportunities

Read more on the UN Treaty

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Policy & Advocacy – 5

Natural Polymers Coalition – A GO!PHA Initiative

Inter-organizational advocacy effort

- The coalition seeks to navigate policy accommodations and recognition for this distinct category, emphasizing the need for a clear definition of natural polymers
- A primary goal is to redefine natural polymers to include circular, sustainable variants produced via nature-identical industrial processes, integrating renewable carbon, recyclability, and biodegradability
- Engaging the EU Commission for inclusive language on natural polymers

Opportunities

- Regulatory frameworks should adapt to rapid innovation in natural polymers, fostering flexibility for emerging technologies
- Collaborative dialogue to craft regulations that effectively balance industry growth and sustainable practices

Challenges

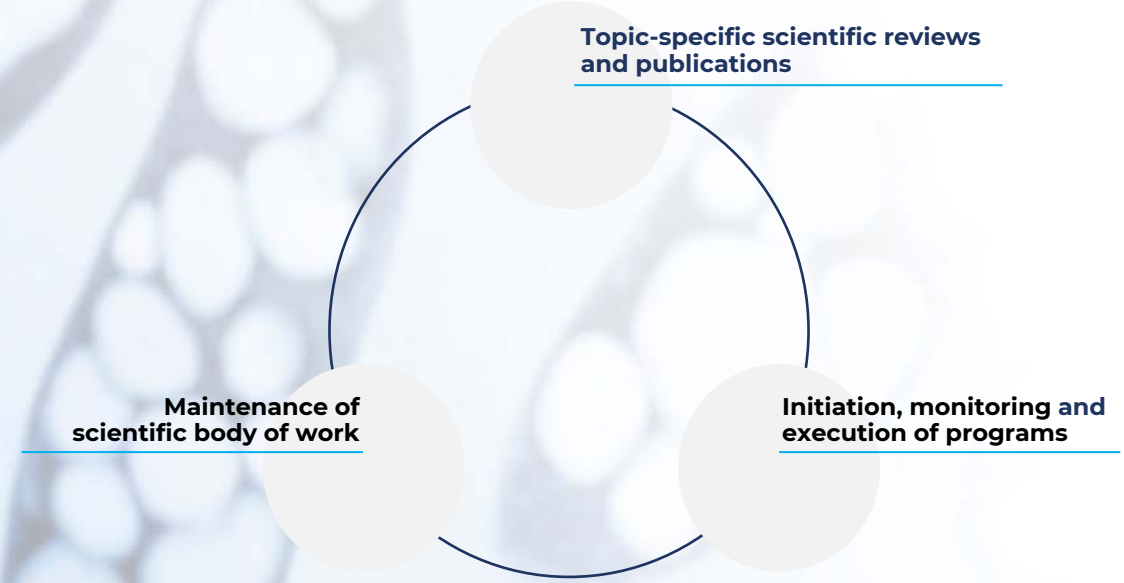
- Lack of clarity in definitions and inconsistency in EU policies
- Despite EU-funded innovation projects in the natural polymers space, there is a lack of alignment with policy and legislation to integrate such projects in practice

Impact

- Accurate and practical definitions forming the basis of policies, such as the REACH regulation definition of “natural polymers”
- Creating a level playing field for polymers identical to those found in nature and produced through novel industrial bioprocess
- Research and development initiatives
- Growth and investment opportunities

Science with a Systems Approach

Curate and Generate data to drive claims



In Microplastics Free, recyclability, compostability, biodegradability

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Royal Netherlands Institute for Sea Research

“PHA is Natural” Program

A GO!PHA Science & Systems Initiative

- **Samples:** LDPE, Cellulose, PHA
- **Temperatures:** 10, 20, 30 degrees
- **Inoculum:** Sea water

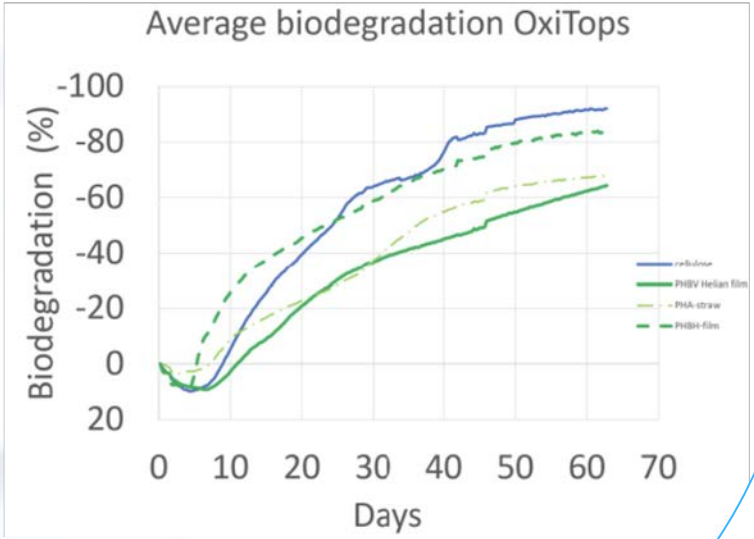
Key Insights:

- Ecoware straws and other PHA forms demonstrated successful biodegradation in natural seawater/sediment settings.
- The study highlighted the influence of microbial composition, regional nuances, and seasonal changes on biodegradation rates.

Next Steps:

- Explore more insights in our full report! Contact gopha@gopha.org for access.

Check out the program here!



Repeat in the five Gyres

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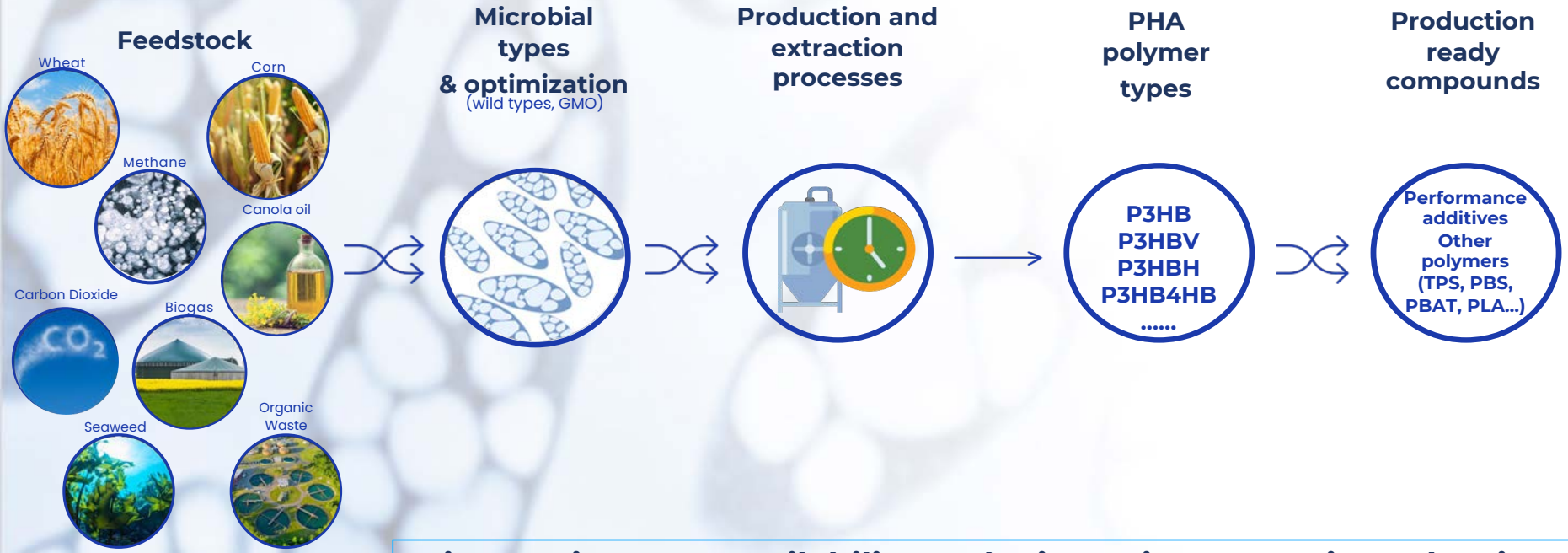
Feedstock diversification,
Advancement in Production



Is increasing PHA availability, reducing price – Spurring adoption

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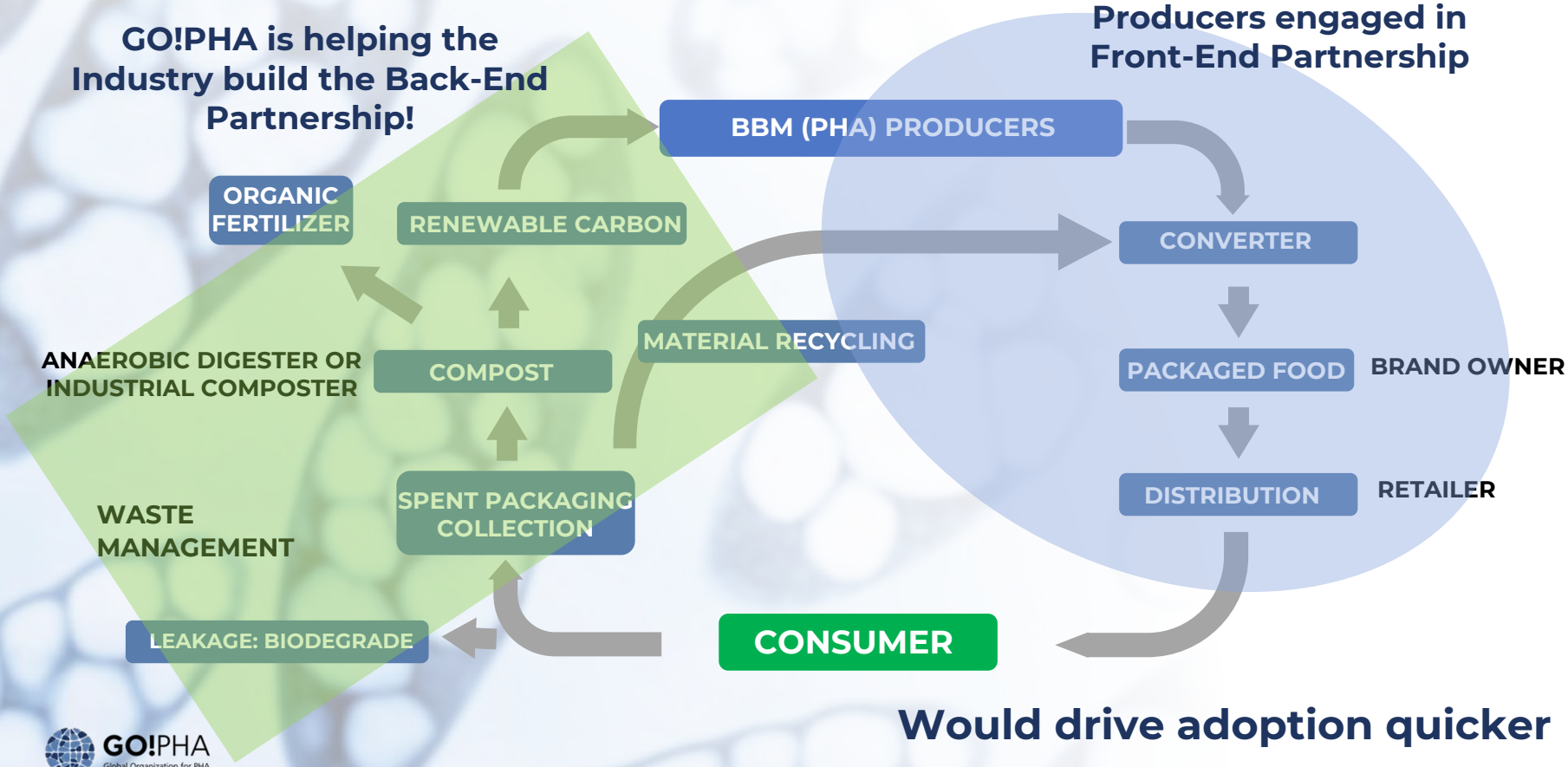
Embracing the entire value chain



Would drive adoption quicker

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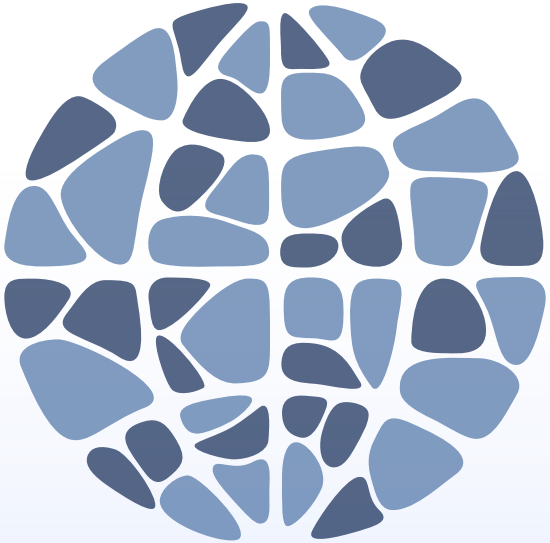

Share. Collaborate. Contribute.

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