

Is Biodegradable/Compostable Plastics a Solution to Managing Plastics Wastes at End-of-Life (EoL) ???

Biodegradable Vs Compostable Plastics ???

BioPlastics; Biobased Plastics???



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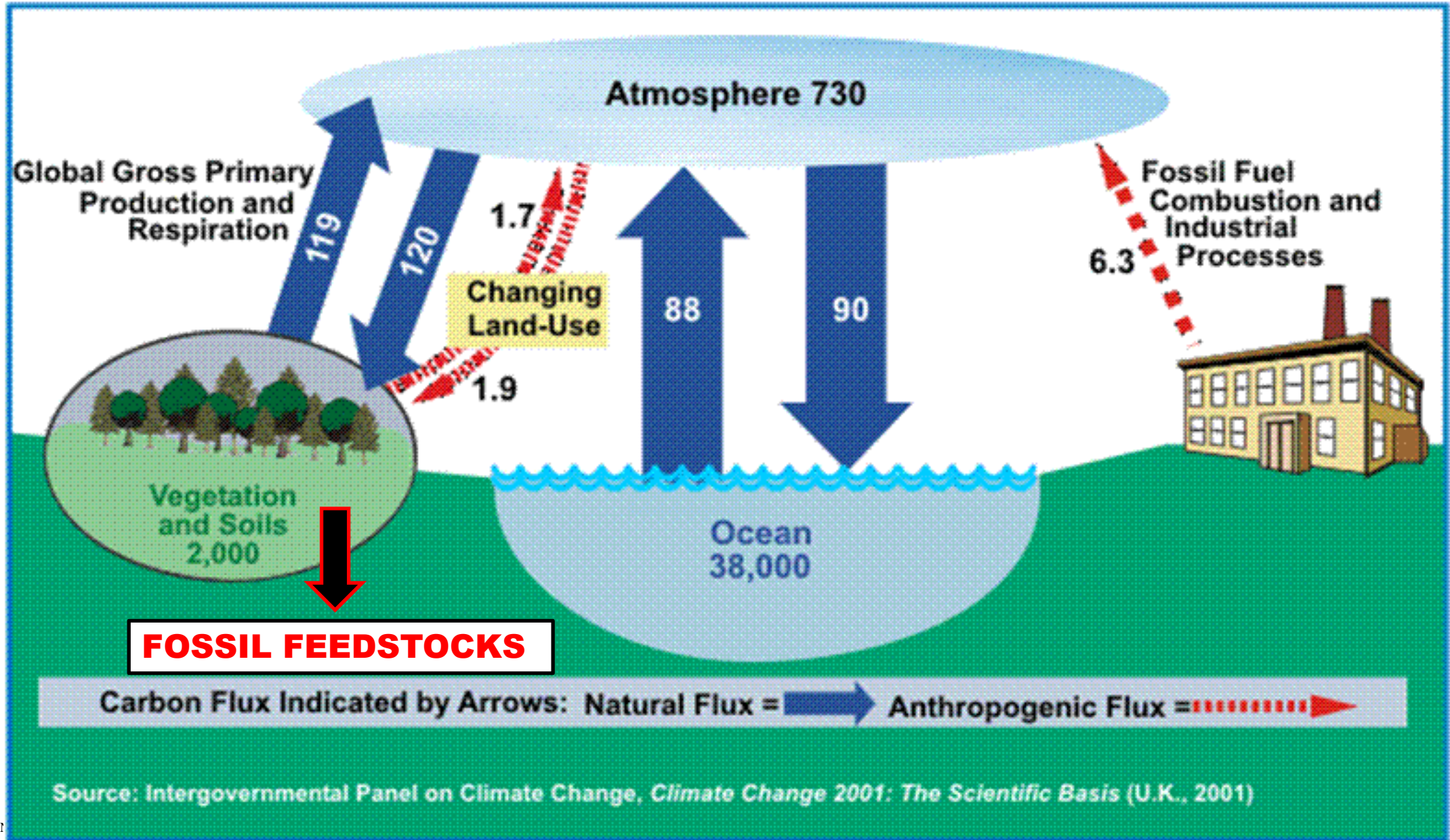
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Lessons from Nature!



Lessons from Nature – Managing Carbon



PAPER/WOOD/BAMBOO VS PLASTICS

Plastics are **lightweight** (energy saving), low-cost, readily processable, and command unique and versatile properties like **transparency**, protection & preservation, **safety and hygiene**.

Factoids: Paper vs Plastic



The production of paper bags generates 70 percent more air and 50 times more water pollutants than production of plastic bags.

Air pollutants



Water pollutants



It takes 98% less energy to recycle a pound of plastic than it takes to recycle a pound of paper.

Energy used to recycle bags:



But recycling rates of both types of bags are extremely low.

Two issues that need urgent resolution:

Beginning of Life -- carbon footprint reductions (use plant-biomass renewable carbon in place of petro-fossil carbon)

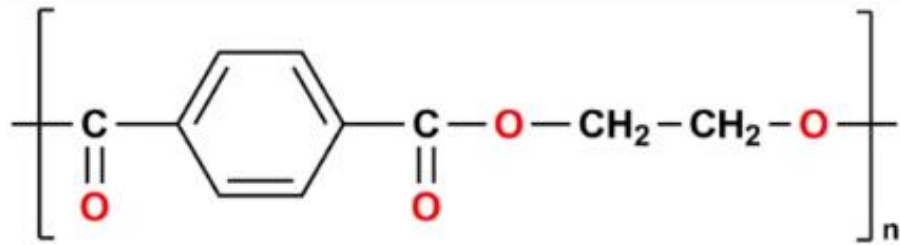
End-of life —the ubiquitous, light weight, **persistent (non-biodegradable) & accumulating** plastics are everywhere, polluting the land and the oceans.

BACKGROUND

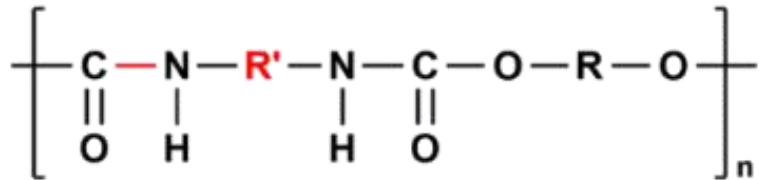
U.S. Plastics Pact (Recycling Partnership, WWF) as part of the EMF Global Plastics Pact

1. Identify packaging designated as problematic or unnecessary and eliminate them by 2025
2. 100% of plastic packaging will be reusable, recyclable, or **compostable** by 2025
3. By 2025, undertake ambitious actions to effectively recycle or **compost** 50% of plastic packaging
4. By 2025, the average recycled content or responsibly sourced bio-based content in plastic packaging will be 30%

**Global Plastics production
454 million metric tons; 2018**



PET-Ester backbone



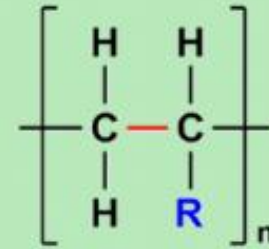
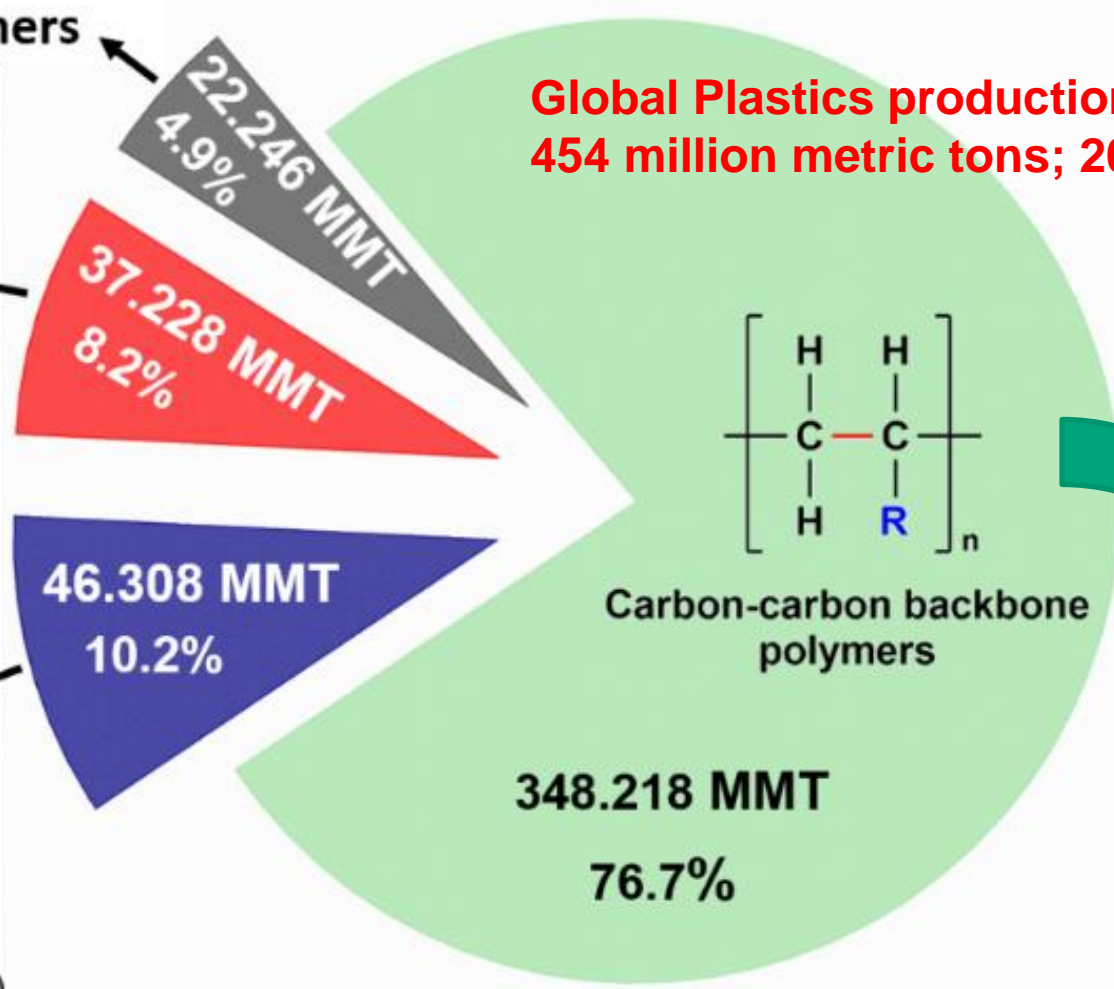
PU-Urethane backbone

R = -H; polyethylene (LDPE, LLDPE, HDPE)

R = -CH₂-C₆H₅; polystyrene (PS)

R = -CH₃; polypropylene (PP)

R = -Cl; polyvinyl chloride (PVC)



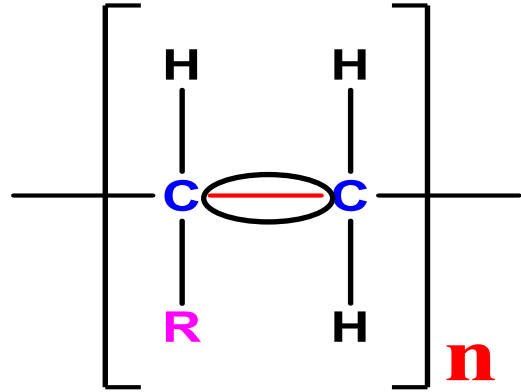
**Carbon-carbon backbone
polymers**

Year 2018

90% non-durable, disposable (necessary) packaging



END-OF-LIFE; Plastics waste (non-durable packaging & consumer products) management



R = -H; Polyethylenes (HDPE, LDPE, LLDPE)

R = -CH₃; Polypropylenes (PPs)

R = -CH₂-C₆H₅; Polystyrene (PS)

R = -Cl; Poly(vinyl chloride) : PVC

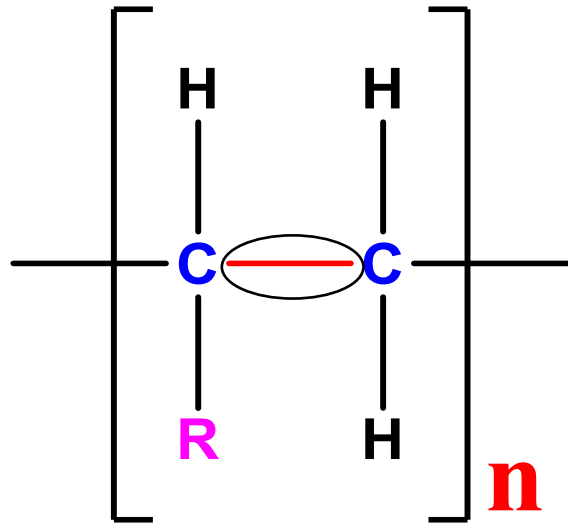
Carbon-Carbon backbone

ubiquitous, light weight, persistent (non-biodegradable) plastics are everywhere, polluting the land and the oceans – mismanaged plastic wastes

Source of “microplastics”

- Thermal cracking, including pyrolysis requires high temperatures (400C+) and gives a mixture of products – gases, liquid products, waxes and tar residue – chemical recycling?
- **Claims around oxo; chemical or biological additives; enzymes/microbes break down – C-C- bonds to small molecules around ambient temperatures that is BIODEGRADED!**

Take home message – Additive technologies will not remove hydrocarbon plastics from the environment in a **practical timeframe**



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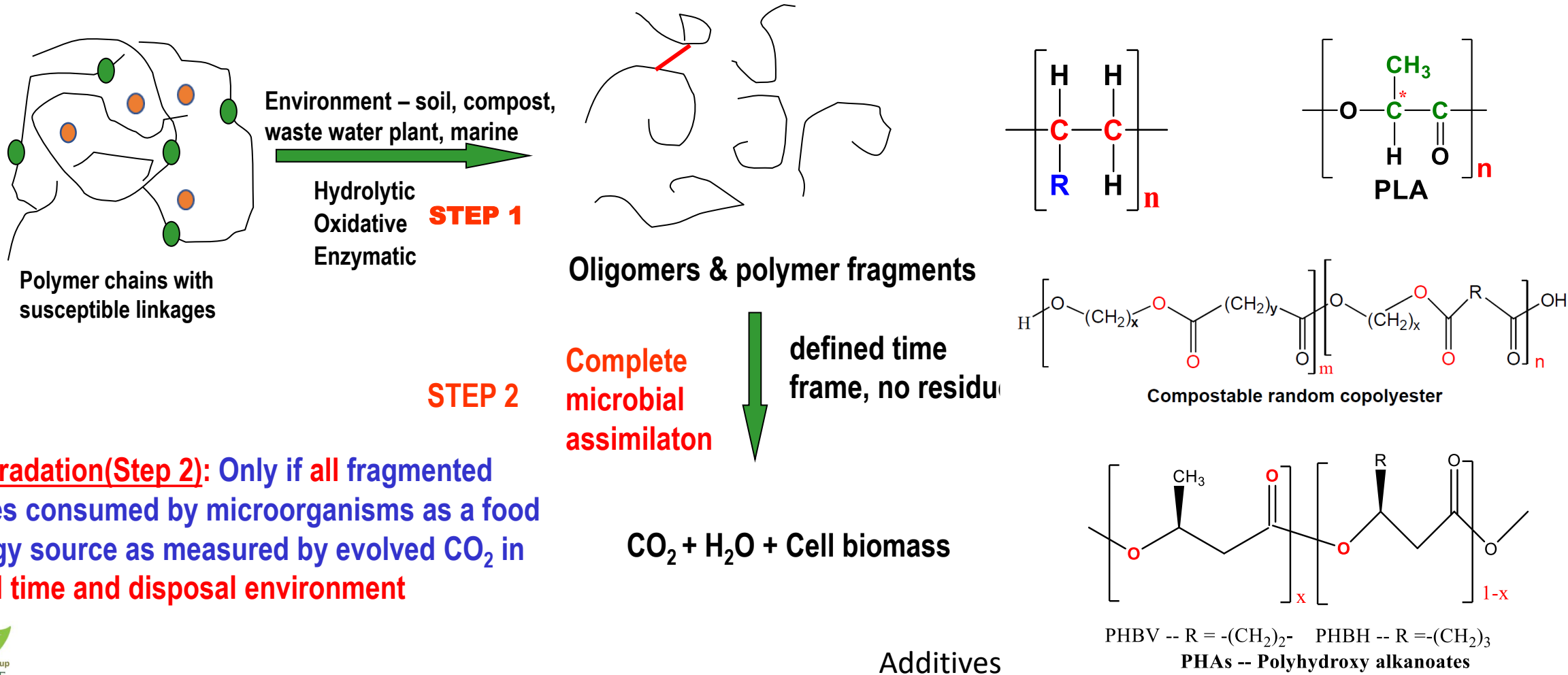
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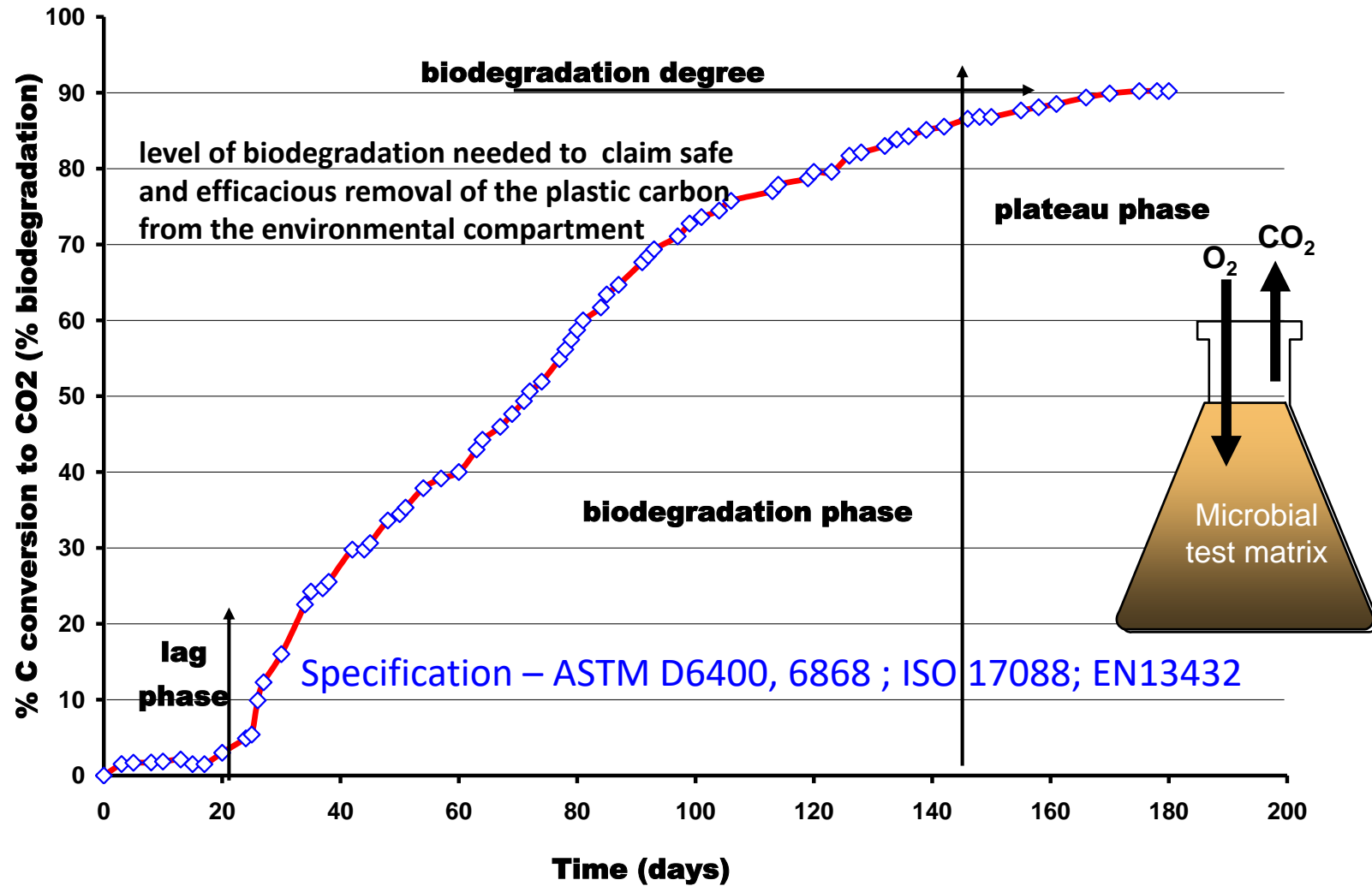
Source of “microplastics”

What does “Biodegradable” Mean?

Can microorganisms in the disposal environment (composting, soil, anaerobic digester) assimilate/utilize the carbon substrate as food source and **completely remove it from the environment in a short measurable time?**



Biodegradation(Step 2): Only if all fragmented residues consumed by microorganisms as a food & energy source as measured by evolved CO_2 in defined time and disposal environment



ASTM D5988; ISO 17556 -- Soil biodegradability test method

EN 17033 – soil biodegradability specifications for biodegradable mulch film

COMPOST -- ASTM D5338; ISO 14855; ISO 18606; EN 13432 AS 4736 & 5810

Specification – ASTM D6400, 6868 ; ISO 17088; EN13432

Composting vs Biodegradability

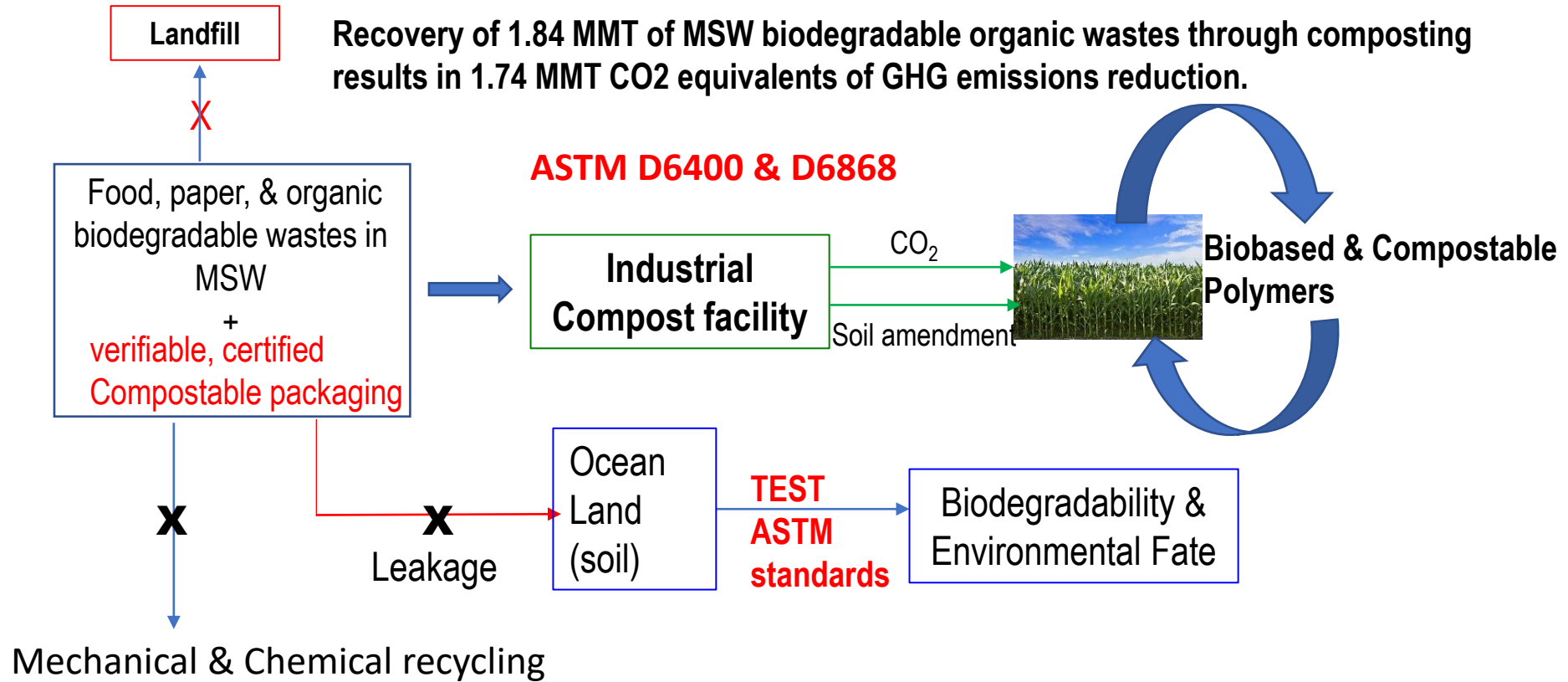
Composting is a managed process to convert unstable and potentially pathogenic, disease causing, odorous, food & biodegradable organic wastes (50% + of the MSW) to a 70% volume reduced, stable soil amendment product (called compost) using **natural mesophilic and thermophilic microbial consortium** life processes

It is a waste management process

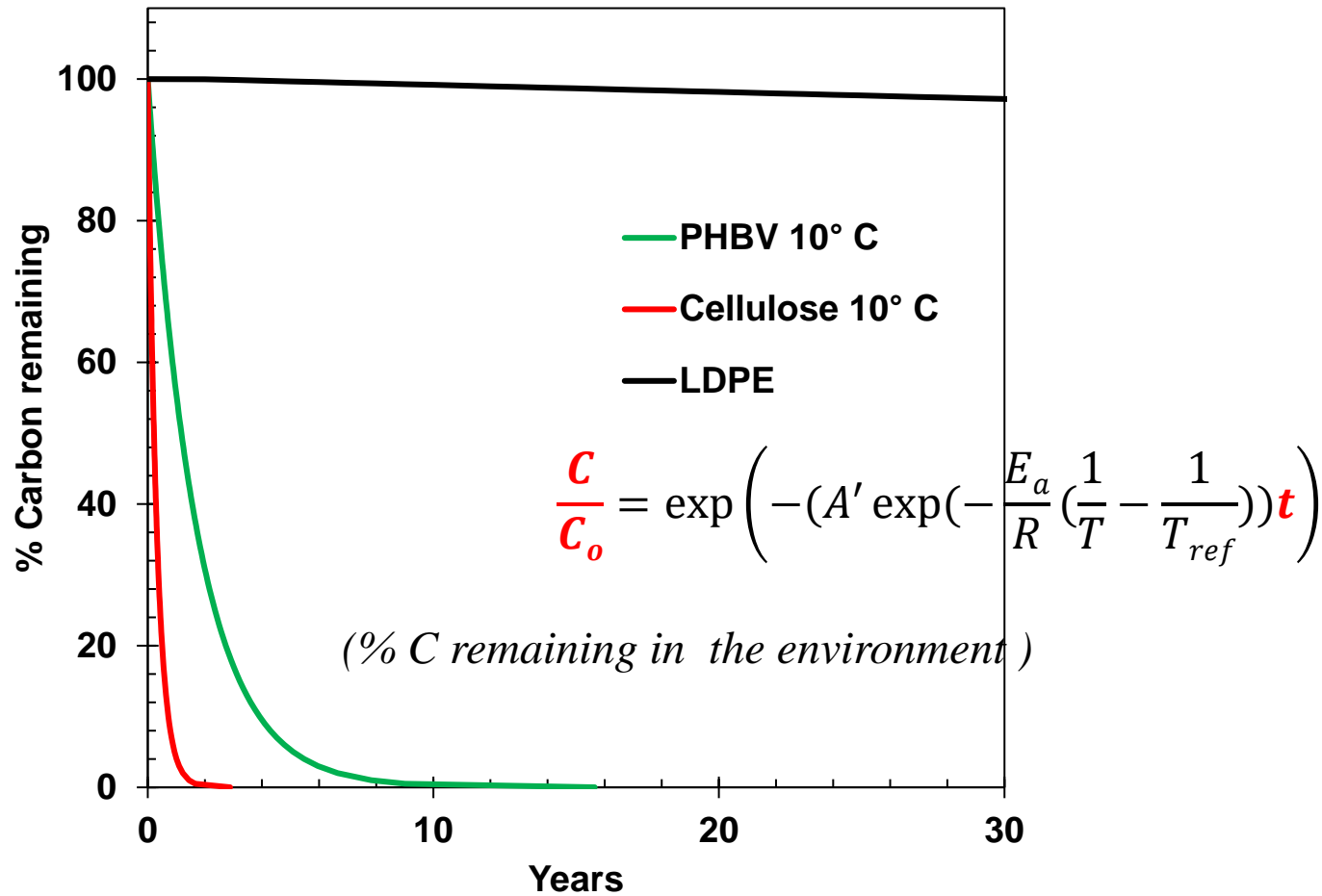
Microorganisms utilize the carbon as food/fuel for energy to drive its life processes.

Microorganisms transport small carbon molecules (not polymer molecules) into the cell

50% + of organic **biodegradable** wastes goes to landfills or dumps leads to methane generation – 25X GWP



Managing plastic wastes through industrial composting (Biological/Organic Recycling)



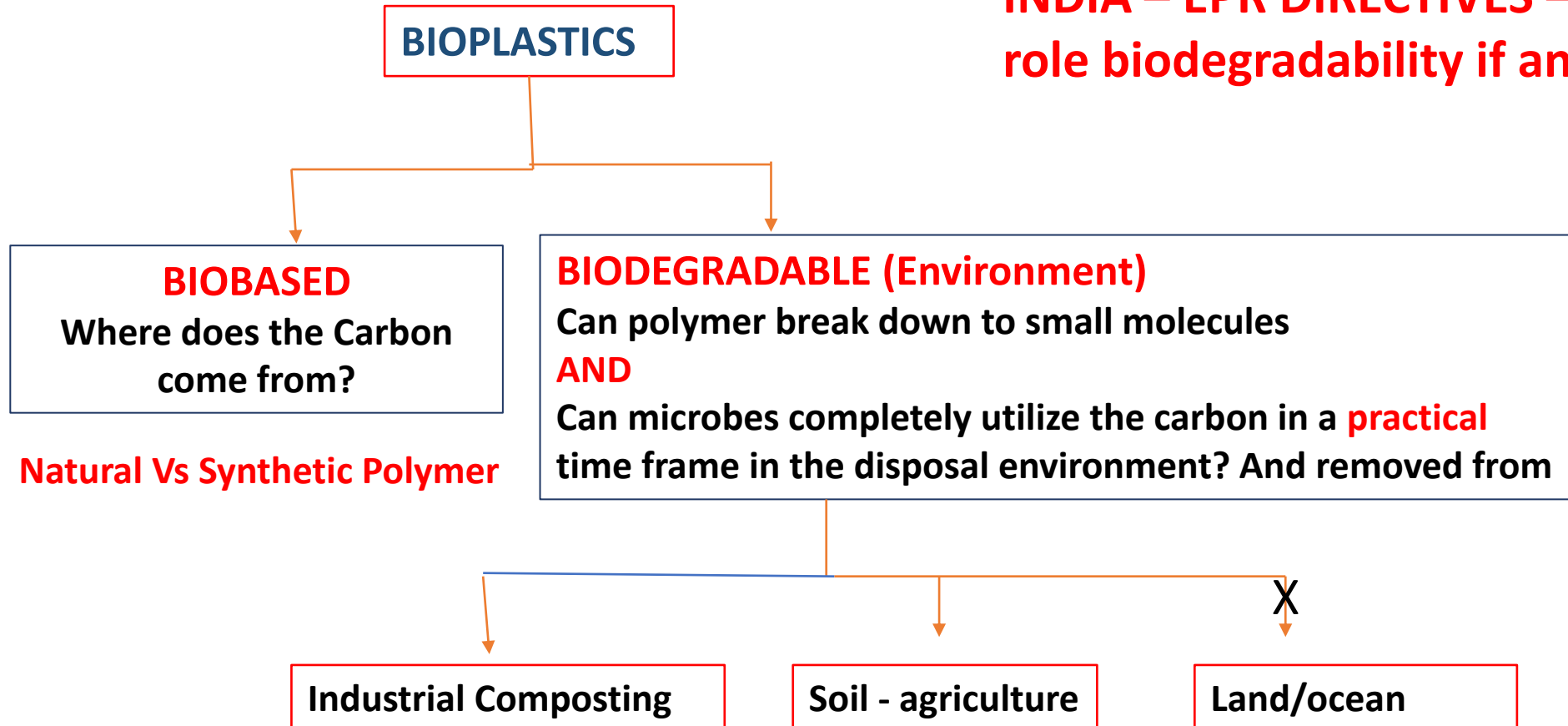
% C remaining	Estimated time required for biodegradation (years)	
	Cellulose 10 C	PHBV 10 C
100	0.00	0.00
90	0.03	0.18
80	0.07	0.38
70	0.11	0.61
60	0.16	0.87
50	0.22	1.18
40	0.29	1.56
30	0.38	2.05
20	0.50	2.74
10	0.72	3.91
5	0.94	5.09
1	1.44	7.83
0.01	2.88	14.96

Global kinetic model using Arrhenius equation and rate law equation – Kulkarni & Narayan -- 2022

SUMMARY

PLASTICS – Carbon containing long chain polymer molecule

INDIA – EPR DIRECTIVES – What role biodegradability if any?



CAUTION – Biobased does not equate to being biodegradable-compostable & vice versa

Thank you

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