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THE STATE UNIVERSITY
OF NEW JERSEY

OPTIONS TO ELIMINATE WASTE PLASTICS POLLUTION

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Plastics!!

- Fossil-based plastics have significant role in our lives.
- We use at least 10-15 items either full or partially made out of plastics . i.e. medical devices, phones, efficient food storage and cars.
- Low-cost production since virgin fossil-based plastic feedstocks are cheap and abundant!
- i.e. Plastics have become an integral part of agriculture at least for the last 40-50 years.
- The total US agricultural plastics generation is approx. 400,000 tons/year.

Environmental Footprint of Plastics:

- Production is highly dependent on virgin fossil feedstock (NG and oil).
- The OECD estimates that the life-cycle emissions of plastics – which includes the production of the material and its disposal – was **1.8 billion tons**.
- It takes approx. 22 gallons (83 liters)of water to make a lb. of plastic.
- Land degradation and water contamination and impacts to food systems are extreme.
- UN estimated that the natural capital cost of plastics on environmental degradation, climate change and health to be about $75B /year

*-http://www.stapgef.org/sites/default/files/documents/PLASTICS%20formatted%20for%20posting.pdf
-Jones, Matthew W., Peters, Glen P., Gasser, Thomas, Andrew, Robbie M., Schwingshackl, Clemens, Gütschow, Johannes, Houghton, Richard A., Friedlingstein, Pierre, Pongratz, Julia, & Le Quéré, Corinne. (2023). National contributions to climate change due to historical emissions of carbon dioxide, methane and nitrous oxide [Data set]. In Scientific Data (2023.1)

Environmental Footprint of Plastics:

- Most plastics contain toxic chemical additives including persistent organic pollutants (POP) that may be linked to cancer, mental, reproductive and developmental diseases.

- Short-chain chlorinated paraffins (SCCP), polychlorinated biphenyls (PCBs), polybromodiphenyl (PBDEs including tetrabromodiphenyl ether (tetraBDE), pentabromodiphenyl ether (pentaDBE), octabromodiphenyl ether (octaBDE) and decabromodiphenyl ether (decaBDE)), as well as endocrine disruptors such as bisphenol A (BPA) and phthalate.

- Close relationship with per- and polyfluoroalkyl substances a.k.a. **PFAS "forever chemicals"**

BIOBASED PLASTICS:
Solution or addition to the problem???

- **Biobased non-biodegradable** polymers such as bio-polyethylene (bio-PE) and bio-polyethylene terephthalate (bio-PET), also referred to as 'drop-in' polymers, offer virtually identical properties to their fossil fuel-based counterparts.

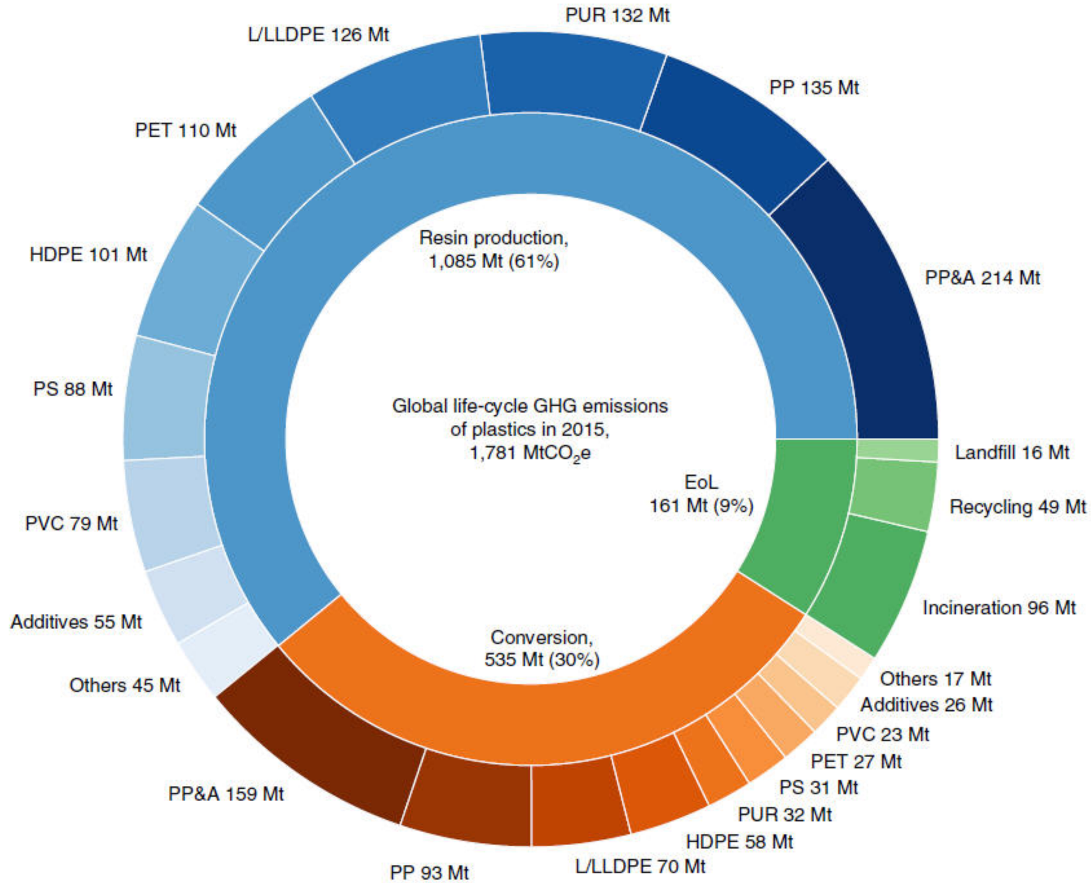
- **Biobased biodegradable** polymers, such as polylactic acid (PLA), polyhydroxyalkanoates (PHAs) and thermoplastic starch (TPS), display different mechanical and chemical properties.

- The net environmental effects of the substitution of fossil-based plastics by biobased plastics are not straightforward due to their potential to drive land-use changes, such as deforestation, that may lead to significant GHG emissions and to reduction of carbon sinks.*

*https://www.oecd.org/en/publications/climate-change-and-plastics_5e0bfe87-en.html

Where to start eliminating plastics pollution?

- Need Policies for:
  - **Restraining plastics demand**
  - Plastics lifecycle emissions policies to address both plastics pollution and climate change mitigation
  - Improved /Innovative recycling
  - Closing leakage pathways to the environment



Zheng, J. and Suh, S., 2019, “Strategies to reduce the global carbon footprint of plastics”, Nature Climate Change, 9, 374-378.

Mechanical Recycling

- Waste plastics are recycled into “new” (secondary) raw materials without changing the basic structure of the polymer.
- Mixed plastics pass through manual or automated mechanical sorting processes.
- The proper identification of materials is essential for achieving a maximized purity of recyclates.
- Various technologies near infrared spectroscopy (NIR), laser or x-ray techniques are available. After cleaning and grinding processes, the material is recovered by remelting and regranulating.
- The resulting recyclates can be processed with all common technologies of plastics conversion.

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Recycled Waste Plastics as Products*

Product (Granules)	Applications	Quantities (tons/year)	Avoided Primary Materials	Substitution Ratio(%)
rPE	Agricultural seedling trays	2,550	vPE	50
rPE	Horticultural applications: waterproof materials	2,350	vPE	50
rPE	Horticultural applications: water storage materials	2,400	vPE	50
rPP	Turnover boxes, pallets, folding containers	10,000	vPP	30
rPP	Wire reels	100	vPP	30
rPC	Suitcase accessories: Handles, wheels and pull rods	600	vPC	20
rPC	Car interior trims: AC ducts, doorsills, door panels, engine covers, fenders, mud boards, wheel covers, bumpers	6,400	vPC	10
rPP	Household cleaning tools	2,000	vPP	30
rPP and rPC	Other materials sold in retail	11,000	vPP and vPC	30

rPE : Recycled Polyethylene
rPP: Recycled Polypropylene
rPC: Recycled Polypropylene composite

vPE: Virgin Polyethylene
vPP: Virgin Polypropylene
vPC: Virgin Polypropylene composite

*Gu,F., Guo, J., Zhang, W., Summers, P.A., Hall, 2017,"From waste plastics to industrial raw materials: A life cycle assessment of mechanical plastic recycling practice based on a real-world case study" , Science of the Total Environment, 601-602, 1192-1207

Waste Plastics as Feedstocks*

Types	Materials	Sources	Quantities (Tons/year)
Film roll offcuts	LDPE	Plastic film manufacturing	1,500
Rejects and offcuts	PP	Plastic product manufacturing	14,000
Extrudates	PP	Plastic product manufacturing	200
Plastics shells and panels of refrigerators	PP	WEEE dismantling plants	6,000
Tanks of Washing Machines	PP	WEEE dismantling plants	2,500
Agricultural Films	LDPE	PSW collectors	2,400
Bottle caps	PP	PSW collectors	400
Post-consumer bags and cases	LDPE & HDPE	PSW collectors	1,000
Post-consumer baskets, boxes and other containers	PP	PSW treatment plants	6,000

LDPE : Low density Polyethylene

HDPE: High density Polyethylene

PP: Polypropylene

WEEE: Waste Electronic & electric equipment

PSW: Plastic solid waste

*Gu,F., Guo, J., Zhang, W., Summers, P.A., Hall, 2017,"From waste plastics to industrial raw materials: A life cycle assessment of mechanical plastic recycling practice based on a real-world case study" , Science of the Total Environment, 601-602, 1192-1207

Chemical Recycling

- **Dissolution** removes additives from the polymers by immersing them in solvents. The plastic dissolves, returning it to the polymer stage. The polymers can then be reformulated into new recycled plastics.
- **Depolymerization** uses chemistry, solvents, and heat to turn polymers back into smaller molecules (monomers), which are then fed back into the plastic production process as secondary raw materials.
- **Conversion** also uses chemistry, heat or catalytic processes in a reactor to break down the plastic waste.

https://pryme-cleantech.com/chemical-recycling

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Thermochemical Recycling*

- Through **Gasification and Pyrolysis**, plastic waste can be converted into chemical intermediates and building blocks that can displace virgin fossil feedstocks.
- ***Pyrolysis-*** Mixed plastics pyrolysis with or without catalysis can utilize plastics as feedstock for BTX (Benzene-Toluene-Xylene) aromatics which are fundamental building blocks of many chemicals and products.
- ***Gasification-*** Product syngas (CO +H2) can be further processed into chemicals and fuels. Through synthesis platform chemicals such as Methanol be produced from syngas. Methanol-to olefins and new products.

Guran, S., 2019, "Options to feed plastic waste back into the manufacturing industry to achieve circular carbon economy" AIMS Environmental Science, 6(5): 341-355. DOI: 10.3934/environsci.2019.5.341

Solutions for Consideration

- Sustainable Business models
- Consumer & Business partnership for urban –industrial symbiosis
- **Education & Outreach**
- Policy
  - Ban on certain types of plastics i.e. single use plastics
  - Potential Surcharges to other plastics to support cleanup and research
  - Taxes, extended producer responsibility
  - Standards for circular design plastics
  - Science-based decision making

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Need to Plan Ahead!

- Short term
  - Engage decision makers & policy makers
  - Avoid contamination
  - Improved collection and sorting (source separated recycling!)
  - Enable secondary markets
  - Innovative thinking to reduce the leakage of plastics into the natural systems

We Need to Plan Ahead!

- Mid- & long-term
  - Innovative thinking in creation of after-use plastics economy
  - Investment on better packaging
  - Policies and Intervention for decoupling plastics from fossil feedstocks
  - R&D on renewable feedstocks for plastics
  - Decouple plastics from fossil feedstocks

Every New Emerging Solution Requires

- Successful demonstration
- Technology Push & Policy Pull
- Participation & markets
- Education & Outreach
- Correct messaging to avoid misinterpretation
- Reliable transparent data
- Correct LCA

Thank You!

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