

National Geographic



NOAA



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Plastics in Our Bodies and in the Environment

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Master Watershed Steward Program



PennState Extension



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You know the problems of plastics...

- From 1950-2017, only 9% were recycled world wide (National Geographic).
- In 2015, ab 55% of global plastic waste was discarded, 25% incinerated, 20% was recycled (U. Oxford).
- Developing economies have little capacity to recycle -almost 0%/yr.
- In China and Southeast Asia, 4 to 12 metric tons enters the oceans every year by informal dumping and from streams/rivers. (D'Ambrières, Field Actions Sci Rep 2019). **How much are WE responsible for dumping in the rivers/oceans?**
- The high demand for plastics in Asia led to exportation to Asia from other continents. China and increasing number of Southeast Asian countries are banning post-consumer plastic importation.
- The production of 'bioplastics' is about 1% of global plastics (U. Oxford). Must be biodegraded with high heat by special facilities, uv & moisture.

How Long until It Is Gone? (projections)

Depends on the amount of moisture and heat present

- **Cardboard box and apple core** – 2 months
- **Cotton shirt** – 2-5 months
- **Wool socks** – 1-5 years
- **Waxed carton** – 5 years
- **Cigarette butt** – 1.5 to 10 years
- **Plastic grocery bag** – 15-1000 years
- **Paper cup** – more than 20 years
- **Nylon** – 30-40 years
- **Tin can** – 50 years
- **Tires and rubber shoe/boot soles** – 50-100 years
- **Alkaline batteries** – 100 years
- **Aluminum can** – 200 years
- **Plastic beverage holder** – 400 years
- **Disposable diaper and plastic bottle** – ~500 years
- **Fishing line** – 600 years
- **Foam buoy, styrofoam cup** – practicably, never

US MSW Generation, 2015*

Waste Material	Weight Generated	Weight Recycled	Weight Incinerated For Energy	Weight Landfilled	% Recycled	% Incinerated	% Landfilled
Plastics	34.50	3.14	5.35	26.01	9.1	15.5	75.4

MSW: municipal solid waste. Given in millions of tons.

These numbers do not include leakage to the natural environment!!

*USEPA, (2018). "Advancing Sustainable Materials Management: (2015) Fact Sheet- Assessing Trends in Material Generation, Recycling, Composting, Combustion with Energy Recovery and Landfilling in the United States

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The % incinerated varies greatly. E.g., in Harrisburg, all is incinerated. Large recycling companies harvest the methane directly to gas turbines for burning and creating electricity.

- ~ 8300 million tons of plastic produced since 1950; 6300 million tons of waste.

AND

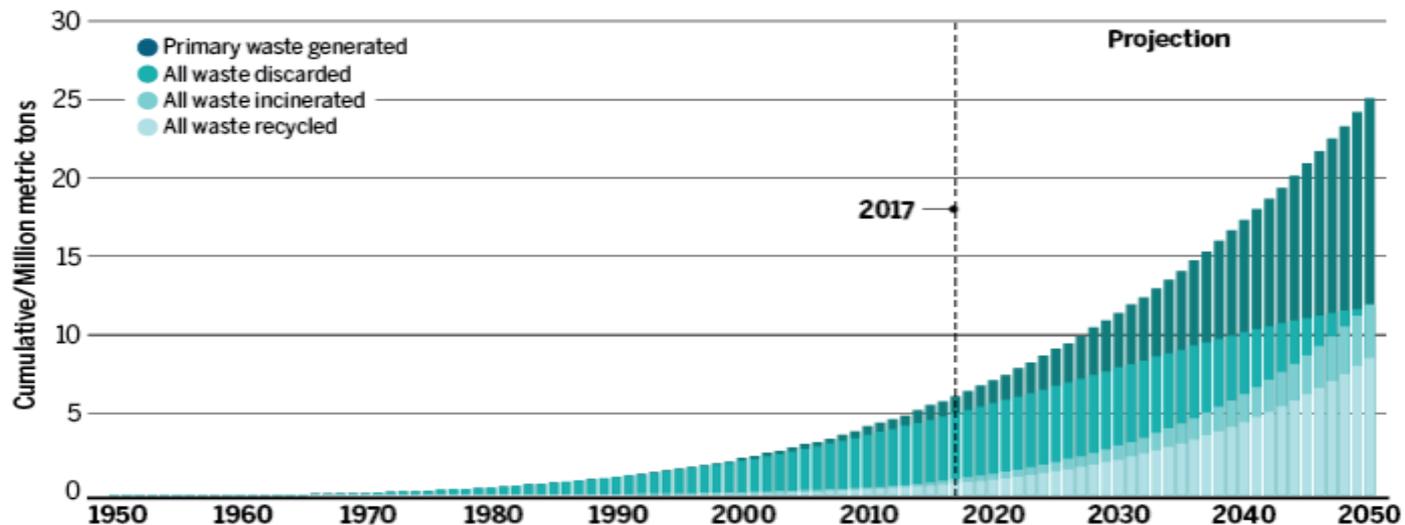
- 300-400 million tons of plastic are manufactured every year.

AND

- In the next 30 y, 4 x more plastic waste than ever before (AAAS, Science, 7/19/17).

By 2050, we'll have produced 26 billion tons of plastic waste

Historical data and projections to 2050 of plastic waste production and disposal. "Primary waste" is plastic becoming waste for the first time and doesn't include waste from plastic that has been recycled.



CREDITS: (GRAPHIC) G. GRULLÓN/SCIENCE; (DATA) GEYER ET AL., SCIENCE ADVANCES

The Clock Is Ticking

**“Why do you [work] like you’re running out of time?...
Do you support this [earth]? Of course. Then defend it”**

(A. Burr and A. Hamilton in Hamilton, by L-M Miranda)

- Every hour - Americans use 2,500,000 plastic bottles, which is the most prolifically produced *consumer* good. Only 14% of are recycled.
- In a week - 10 billion plastic bags used worldwide. The average American family takes home almost 1,500 bags a year.
- In a lifetime – the average American will personally throw away 600 times his/her bodyweight of plastic.
- Exfoliating washes and toothpaste contained polyethylene microbeads. Microbeads were outlawed for sales as of 7/2018, and producers had until 7/2019 for time for safety testing of products that were both cosmetics and non-prescription drugs. Plastics and other toxic chemicals continue to to be sold in detergent (polyethylene, polycarboxylates, quaternium 15, xylene sulfonate). **You must read labels.**
- 93% of Americans test positive for the presence of BPA in their bodies (CDC study from 2003-2004).

Sourced from the University of Tennessee, Dept. of Forestry, Wildlife and Fisheries

Plastic garbage: EPA.gov



Pocono Creek, PA,
March 2018



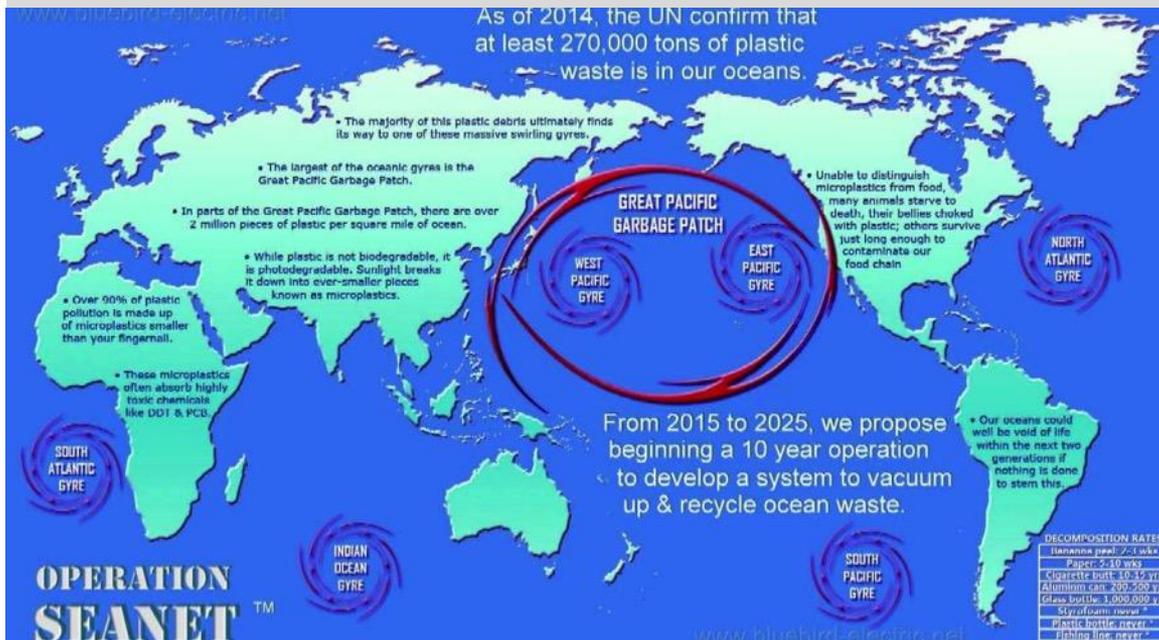
**Sixty years
later, this is the
reality no one
anticipated.**



Marsh at JHNWR-Armstrong

Where do Discarded Plastics Go?

1. *Plastic pollution is the most serious problem affecting the marine environment.*
2. Discarded plastics - 8 million metric tons - make their way into the oceans of the world *each year*.
3. Some accumulate when ocean currents bring them together in large currents – gyres. The currents bring plastics from the surface to the ocean floor.
4. They break down into microplastics (or start that way), and may degrade >500 y.
5. Macroplastics break down into microplastics by interaction with heat, uv, wind, waves, water, temperature, sand and stone, and bacteria.
6. Most plastics are below the surface of the oceans and are found throughout the water column.



National Geographic



T. Roberts video, "The Great Realisation"

The Great Lakes:

20% of the world's available freshwater

Microplastic particles in surface water:

Lake Superior & Huron=7,000 per km²

Lake Erie=47,000 per km²

Lake Ontario=230,000 per km²

Lake Huron=~4000 per km²

As high as 466,000/km² downstream
from two major cities

(Eriksen et al., 2013)

*most common:

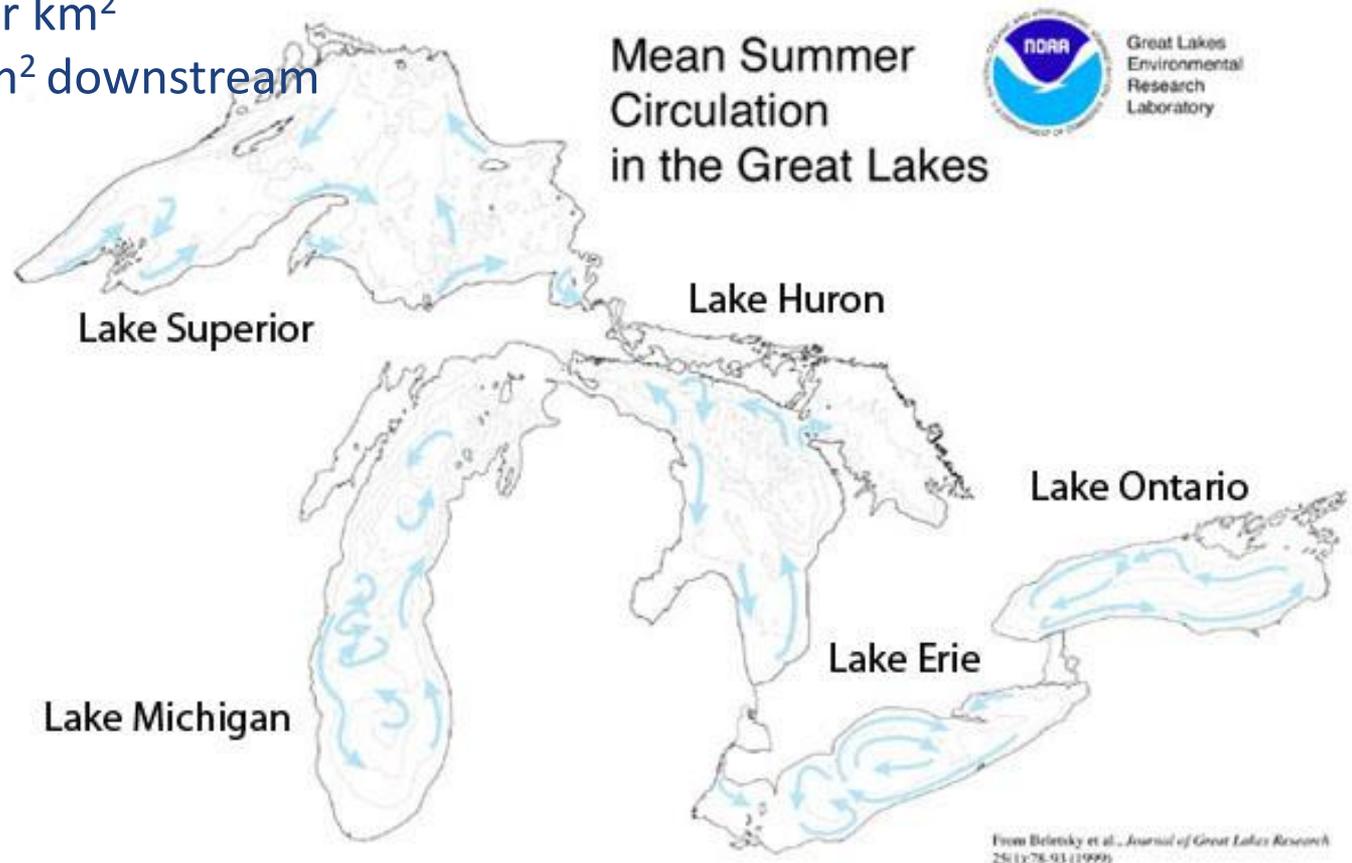
*Fibers

Films

Foams

Line

*Pelletsµbeads





Beached whale in Norwegian waters - 30 plastic bags and large amount of microplastics led to whale's death.



shark



albatross



turtle



sea flea

- Found in most marine species-at least 800.
- In beached whales and other sea animals and birds, there is predictably a great deal of plastic, which will not be digested.
- Plankton eat plastics. Plastics found in animals living in the deepest ocean trenches.
- When an animals eats fish or plankton that has eaten plastic, the toxic chemicals are absorbed. Microplastics lodge in their gills, gastrointestinal tissue.
- Of 485 fish tested, 40% had ingested plastic (Penn State). Plastics affect the organs and behavior of fish. Wildlife suffer **entanglement, suffocation, and starvation**.

MICROPLASTICS



McCormick et al. Microplastic is an abundant and distinct microbial habitat in our fresh water. 2014 Env Sci&Tech

Microplastics are defined as < 5 millimeters in diameter. Nanoplastics are < ~250 nm

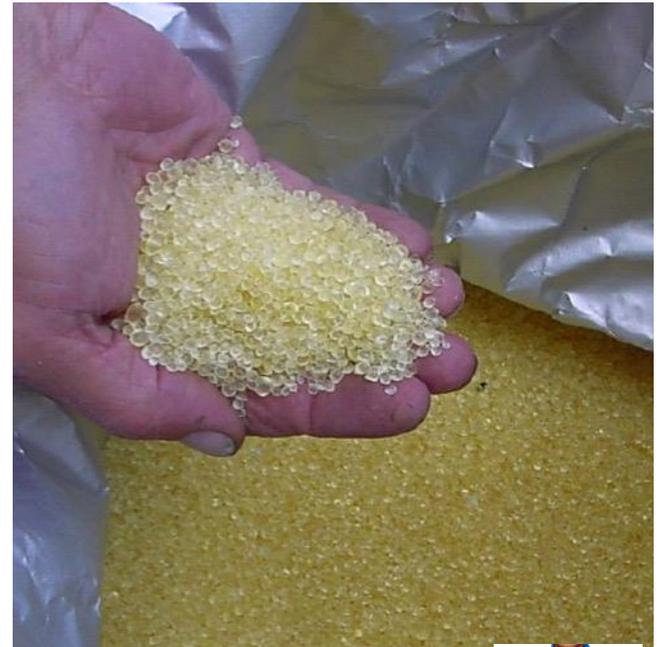
Plastics adsorb persistent pollutants. They leach phthalates, polyethylene (PET), polypropylene (PP), polystyrene, PVC, flame retardants, BPA, UV sun screens, etc. into water.

They provide hard substrate for microbes, and gene sequence analysis identified a diverse microbial community referred to as the plastisphere.

Types of Microplastics (<5mm)

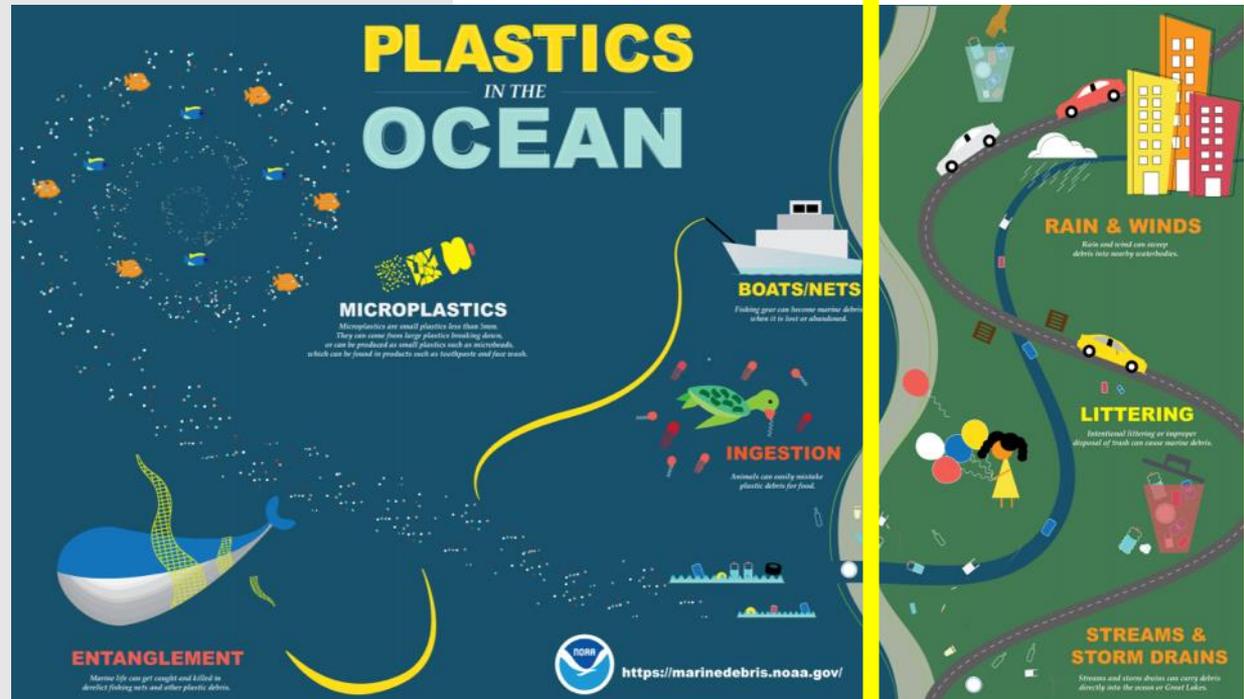
Fragments of larger plastics that have broken down in the environment: micro-pellets, nurdles-virgin plastic for manufacturing.

- Microbeads – tiny pieces of polyethylene plastic that were added to personal care products. Still added to clothing detergent. Look for acrylates, polyethylene, other plastic names.
- Microfibers – small fibers enter the water from washing clothing made of synthetic materials, e.g., polyester, acrylic, and nylon (60% of global clothes). Also in clothing detergent.
- Pellets/nurdles – manufacturing fodder, in toys?
- Line – fishing line and other plastic lines.
- Films – sheets of thin membranes to separate something, hold items, be a barrier, and printable surfaces.
- Foams – structural foams (polyurethane, polycarbonate, polyphenylene oxide, etc), and for bonding to surfaces.



Environmental entry points

- Wastewater treatment facilities, trash bins, drains. WWTP cannot filter all microplastics.
- On-farm applications of sewage sludge
- Atmospheric deposition - greater than previously thought
- Break-up of larger plastics



80% of marine plastics originate from land.

Basic Facts about Plastics

1. Plastics (synthetic polymers) are long chains of monomers with bonds that take hundreds of years to break down. Most are mixtures.
2. Manufacturing plastics creates hazardous waste.
3. >90% produced from fossil fuels by petrochemical companies.
18% of virgin plastic made in NA, 50% Asia, 30% Eur (D'Ambrieres, 2019).
4. Plastic is one of the world's most-used materials; most overt problems are use of fossil fuels, end-of-life disposal, and loss of economic value.
5. Plasticizers, uv absorbers, flame retardants, etc. can diffuse through the polymer and release into any liquid or air that contact the plastic.
6. Chemicals in plastics are **endocrine disruptors** - mimic the action of hormones and other signaling molecules by fitting into/binding with receptor sites in many tissues (also pesticides, pharmaceuticals, PCBs, fungicides, plasticizers (BPA), phthalates (more flex/harder to break) etc.
7. Concern is greatest for fetuses and non-adults: affect early sexual differentiation and neurological development.



What is at risk?



Plastics released to the environment serve as carriers of organic contaminants to life. This pollution *and* plastic additives are transported to animals.

A. Molecular sizes of synthetic polymers are too large to pass through the cell membrane. But, toxic chemicals attached to plastics are of smaller sizes that can penetrate into cells, cross BBB or placenta.



B. Plastic additives (e.g., flame retardant, antimicrobial) leach from plastic and transfer to the tissues of animals. More dense plastics accumulate in sediment where they are eaten by aquatic species (e.g., lugworms, eaten by fish).

- C. The extra 33B tons of plastic on the planet by 2050 raises concerns about habitats where plastics in sediments exceed 5% by mass (Browne et al., 2013).
- D. Both pollutants and additives damage the immune system which is more subject to:
1. Oxidative stress;
 2. Reduced Feeding;
 3. Immune dysfunction;
 4. Mortality.

Can plastics cause diseases?

- Bisphenol A (BPA) – used in polycarbonate plastics often in containers to store food and beverages such as water bottles; and in epoxy resins that coat the inside of metal products such as food cans, bottle tops, water supply lines, some dental sealants and composites – **kidney disease, diabetes II, autism, ADHD, Alzheimer's Dis, Parkinson's Dis**. (Zeliger 2013)
- Phthalates – added to plastics to increase flexibility, transparency, durability, longevity, especially to soften polyvinyl chloride – **diabetes II, cardiovascular dis, hypertension, sexual organs, thyroid, etc** (CDC)
- Persistent Organic Pollutants (POPs) remain in adipose tissue up to 30+ ys – **cancer, immune system suppression, cognitive and neurobehavioral fn, sex steroid and thyroid fn, hypertension, cardiovasc, diabetes** (Carpenter 2011)
- Polynuclear aromatic hydrocarbons (PAHs) – were in higher levels than virgin plastic debris suggesting produced during manufacturing (Van A 2011)
- Lipophilic chemicals: Rates of diagnosis changed from 1990-2010 (Zeliger 2013):
 - **Cognitive, neuropsychiatric, and behavioral disorders increased by >37%**
 - **Parkinson's disease increased by 75%**
 - **Alzheimer's disease increased by 100%**
 - **Autism increased by 30%**
 - **ADHD increased by 16%**
 - **Diabetes increased about 200%**
 - **Cardiovascular disease**

Can these diseases be averted?

World Health Org states that 24% of environmentally associated disease (known by publication in 2006) is caused by environmental exposures that can be averted.

How are we exposed to plastics?

Plastics adsorb contaminants

CONTAMINANTS

- Plastic debris in the water attach with chemicals, like:

A. PCBs – polychlorinated biphenyls

B. PAH – polycyclic aromatic hydrocarbons

C. Petroleum hydrocarbons

D. Organochlorine pesticides and solvents

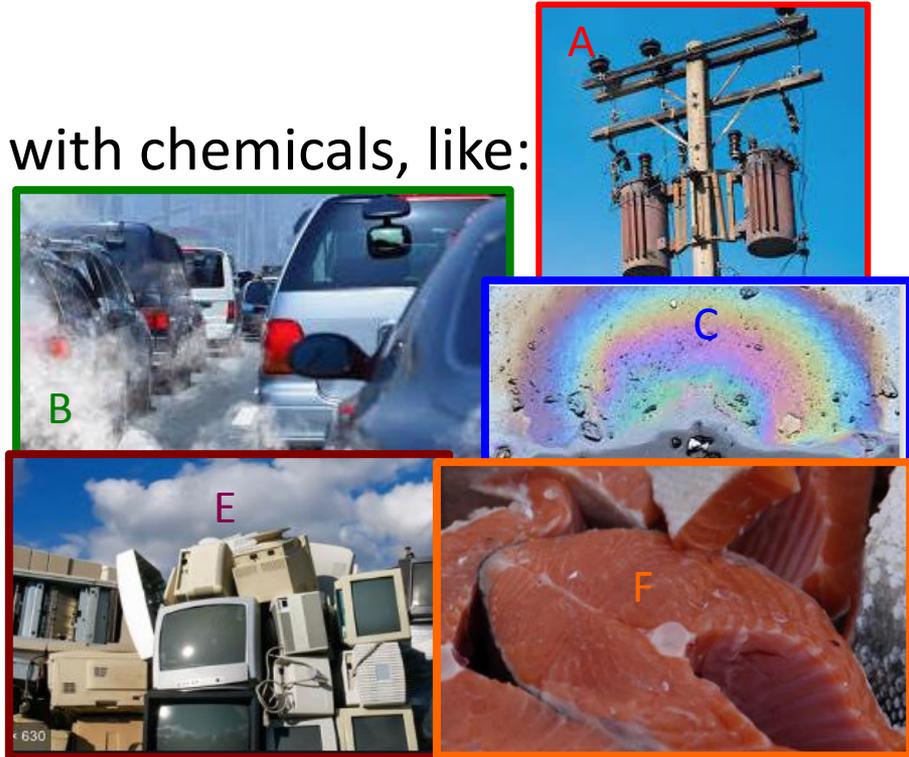
E. Polybrominated diphenylethers

F. Alkylphenols and bisphenol A (BPA)

- SEE EPA's Tox Town site for more info.

PLASTICS

- Polyethylene accumulates more organic contaminants than other plastics. It is the most popular plastic in the world.



Plastics interact with other pollutants such as:



- Silt carrying nutrients
- Fats and grease from food waste
- Detergents
- Agricultural runoff
- Herbicides
- Pesticides
- Pharmaceutical waste
- Eutrophication
- Ocean acidification

Microplastics are stressors for biota and affect growth, reproduction, and species interactions.

1. Continuing release of microplastics through breakdown of littered plastics already present in the environment, and
2. high demand of plastic materials/products will increase, means microplastics may be an increasingly important freshwater pollutant in the future.

A NEW ELEMENT AND EMERGING CONTAMINANT IN THE STREAM ECOLOGICAL HABITAT.

Microplastics in the food chain

- Studies are being done to quantify the amount of microplastics present in the food chain.
- Microplastics are suspected to be present in all parts of the food chain from filter feeders to apex predators. From pole to pole. From mountaintops to bottom of oceans.
- Bioaccumulation leads to higher levels of contamination.
- Biodegradation does not occur because so few organisms use it as a food source.



Are microplastics found in our food?

- Microplastics in the marine environment are transferred to sea salt through sea water. (Yang, D., et al. , 2015. Microplastic pollution in table salts from China. Environ. Sci. Technol; Kosuth et al, 2018. Anthropogenic contamination of tap water, beer, and sea salt. PLOS One)
- Seafood such as swordfish, albacore, bluefin tuna, oysters, shrimp, and mussels ingested and bioaccumulated not only plastics but the toxic chemicals that had been sorbed on microplastics (Rochman, et al., 2013. Ingested plastic transfers hazardous chemicals to fish and induces hepatic stress. Sci. Rep.)
- Microplastics were found in 81% of tap water samples in the U.S. >98% were fibers.(Kosuth, et al.. 2018. PLOS One). Mason et al. found 5.45 particles of plastic/liter, twice the rate found in bottled water (93% of samples from around the globe contained plastics).
- Microplastics found in all of 12 brands of Great Lakes beer (Kosuth, et al., 2018. PLOS One)
- The average person may ingest over 5,800 particles of synthetic debris from sea salt, tap water, and beer each year, with most coming from tap water. Less in ground water, but found in Karst formation (Hoellein et al.).
- There are no federal standards for the amount of plastic that seafood can have when sold for food.
- The World Health Org reported (2019) that based on limited data, there was no significant human health risk from drinking plastics and its biofilms (plastisphere). "No data suggests overt health concerns associated with exposure to microplastic particles through drinking-water." Rationale – low levels, *not* that the chemicals are not harmful to humans. Report did not mention endocrine disruptors and developmental effects.

Microplastics in animal tissues

Potentially the
body is
absorbing,
distributing,
metabolizing,
and excreting
microplastics
(NJ DEP)

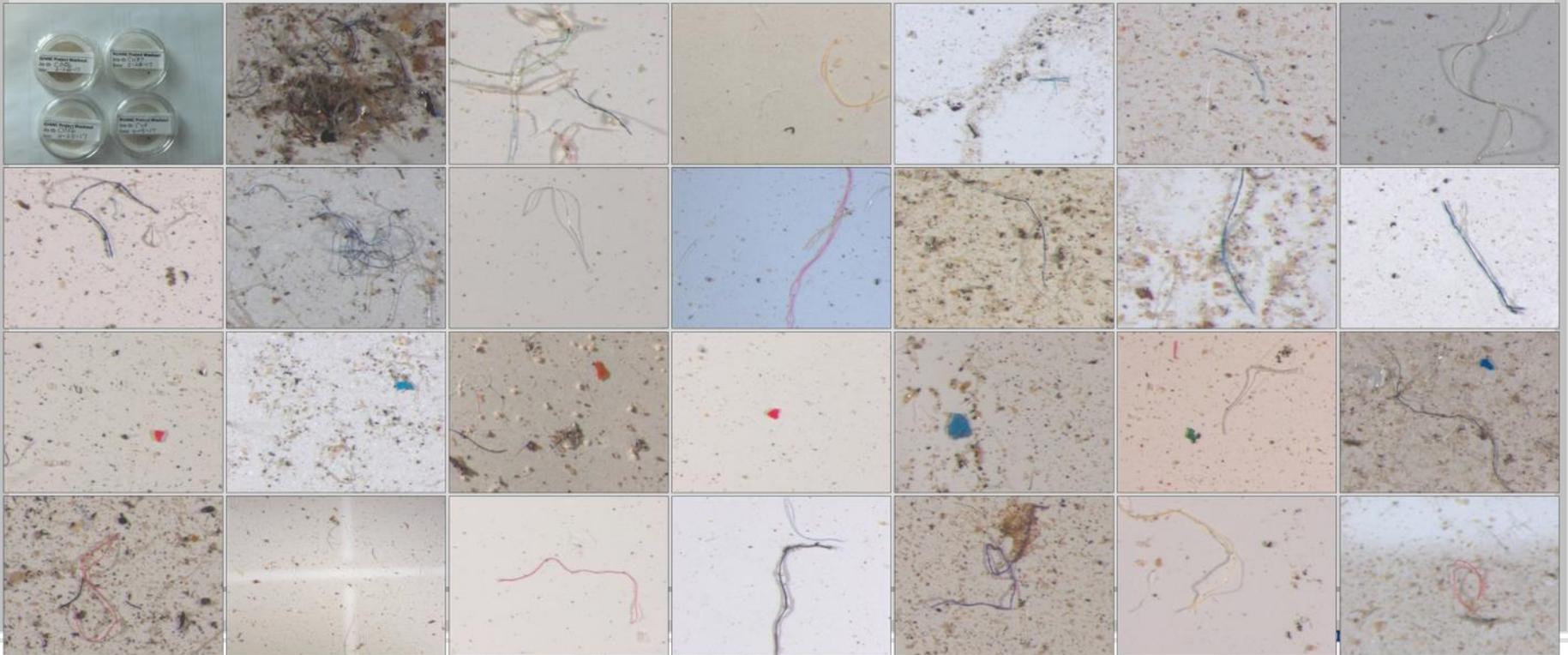
- Austrian Environmental Agency found 9/10 types of plastics in 8/8 humans' stool samples from 8 countries, most commonly polyethylene and polypropylene (bags, bottles, plastic food wrappers, synthetic clothes).
- Polystyrene beads transferred from insect larvae to the gastrointestinal system of adult mosquitoes (Al-Jaibachi et al 2018)
- Microplastic endpoints in fish and mammals: **endocrine, liver, muscle, immune response, gills, circulatory, intestine, olfactory, gonads, respiratory, genes/DNA.** (Smith et al., 2018, review, Curr Env Health Rep.)
- Plastics found in chicken gizzards (digestive tract).
- Plastic beads transferred from rodent placenta to fetus.
- Autopsies of people with knee or hip replacement showed PE particles in abdominal lymph nodes (68%), liver/spleen (14%).
- Terrestrial ecosystems absorb plastic – 1/3 of all plastic waste ends up in soils or freshwaters (Anderson et al. 2018)
- Plastics transferred to soils – Estimate of 110k-730k tonnes of microplastic to agricultural soils/yr in US and Europe (Nizzetto L, 2016). Microplastics interact with soil fauna – earthworms.

What is found in the home?

- Parisian roof top collection of microplastics in 2014. Surface of sampling was 0.325 m² and occurred from 7 to 30 days. **More than 90% were fibres.** Amounts ranged from 29-280 particles per m² per day (\bar{x} =118), and highest amounts found during rainfall though no clear correlation w weather. (Dris et al, 2018).
- ~30% of indoor dust is plastic microfibers (Dris et al., 2017)
- Sources of airborne microplastics are synthetic textiles from clothing and household items, and land-based application of plastics retained in sewage sludge.
- Estimated human exposure from indoor atmospheric fallout - ~68,000 microplastic fibers/year (Catarino et al., 2018).

What is found outside?

- Nov. to March data collection of microplastics deposition in remote Fr. Pyrenees, and found $x=249$ fragments per m^2 per day. (Allen et al., 2019)
- USGS study of CO Rocky Mountains: microscopic plastics were ubiquitous – unexpectedly found in >90% of samples, mainly fibers, greater # in urban than remote sites. (Wetherbee et al., 2019)



What can we do?

Types of Solutions

- Regulatory
- Business Action
- Individual Action
- Community Action
- Science&Technology



Octoraro Reservoir Clean up



Northern Hawaii islands derelict gear clean up

Policy Development

- Understand the presence of plastics and its impacts.
- **First** - Prevent further inputs into freshwater, air, and land. **Second** - Reduce the total amounts in the environment. Solid waste stream must be minimized in streams, estuaries, coasts.
- Develop educational programs.
- Develop standardized monitoring techniques – See NOAA, Laboratory Methods for the Analysis of Microplastics in the Marine Environment.
- Develop research priorities.
- Develop regulatory actions - legislation to address microplastic spills.
- Urge your federal representatives to fund NSF, EPA, and other federal science agencies to engage in systematic studies of chronic low levels of plastic ingestion. Funding not available to scientists currently except from NOAA.

Eerkes-Medrano , et al. 2015. Microplastics in freshwater systems: A review of the emerging threats, identification of knowledge gaps and prioritization of research needs. [Water Research](#).

Thevenon, et al. 2014. Plastic debris in the ocean: The characterization of marine plastics and their env'l impact, situation analysis report. Intl Union for Conservation of Nature and Natural Resources.

Regulatory

Plastic Bag Bans, Fees, and Recycling

States introduced at least 95 bills related to plastic bags in retail settings. The majority of bills propose a ban or fee on bags. Others enacted legislation that preempt local government action or improve bag recycling.

Nat'l Conference of State Legislature - 2019

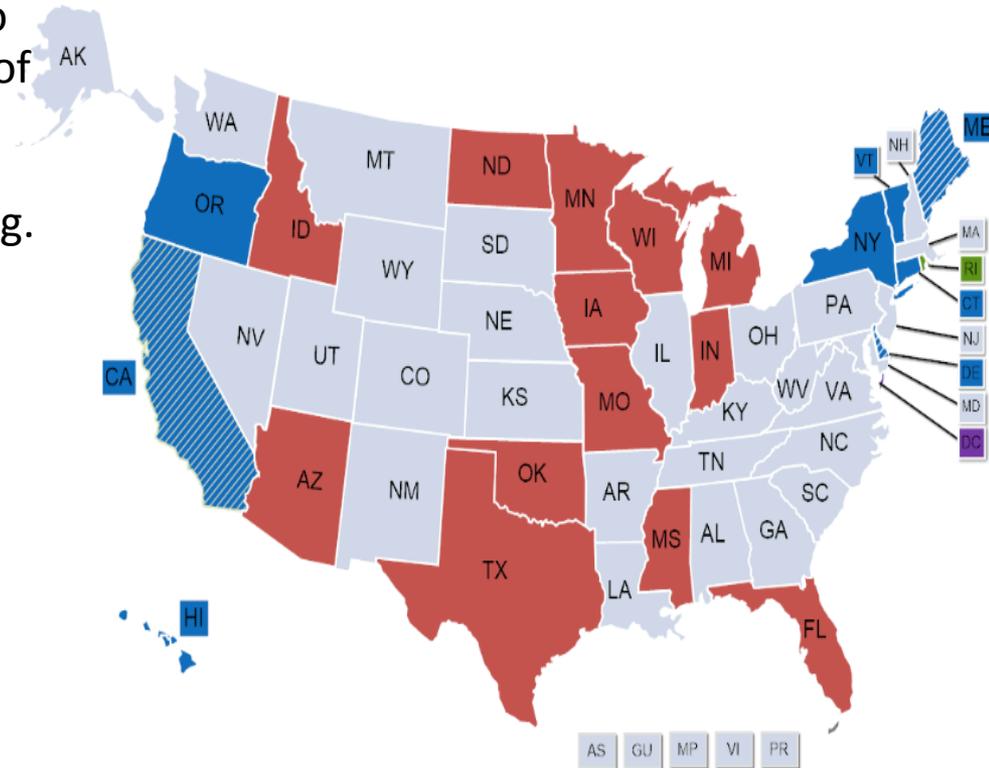
2020: Ten States banned single-use bags

- California
- Maine
- New Jersey
- Connecticut
- New York
- Delaware
- Oregon
- Hawaii
- Vermont

ND, TX, OK, PA preempted local govt.

Canada proposes ban single use plastics by 2021. China announced banning some plastics

Major cities with plastic bag bans &/or fees:
Boston, Chicago, Cleveland, Los Angeles, San Francisco, Seattle, Boulder, Montgomery County MD, NYC, Philadelphia, Portland ME, Portland OR, Washington DC.



LEGEND	
	Bans *HI has a de facto statewide ban
	Fees or Taxes
	Labeling, Recycling or Reuse Programs
	Ban and labeling, recycling, or reuse programs
	Preemption



Regulatory

The status of bans on polystyrene - StyrofoamTM

- PA's ban on polystyrene – status. In 2018 the senate bill died in the Senate Environmental Resources and Energy Committee.
- In 2019, Maryland passed a bill to become the first state in the country to ban polystyrene foam food containers and cups (passed in the House 100-37). It was allowed to become law by Gov. Hogan by not vetoing it.
- In 2019 Maine banned polystyrene foam food containers in restaurants and grocery stores that Gov. Mills signed.
- PA's bill to prevent banning plastics expires when assessment report is to be completed July 1 2020.

Regulatory Actions to Consider

- Restrict alternative methods for managing end-of-life plastics
 - Taxes on landfills (France and UK), or outright bans on landfill disposal. European Union set target of limit of 10% plastic waste to landfill by 2030 (now 30%).
 - Separated collection systems or innovative collection arrangements involving consumers and brands (EU: 90% collection target for plastic bottles by 2025)
 - Cost factors have determined manufacturers purchase of recycled plastic, thus dependent on price of crude oil that can cause volatility in recycling sector. Thus, decouple the market for recycled plastic from the market for raw plastic by requiring recycled plastic in products (EU: beverage containers must contain at least 35% recycled plastic by 2025).
- Innovations in sorting technologies open the possibility of processing new flows and more yield, such as AI. Marginal decrease in production costs can drive the recycling sector.
- Change consumer demands and behaviors - occurring in food industry
- Consumers must be convinced to sort their waste properly, an issue for public authorities to provide guidelines and their standardization.

Basic Economic Facts about Recycling

1. Recycled plastics meet about 10% of global demand for plastic.
2. Cannot always substitute recycled plastics for virgin because must be traceable for food packaging, some uses must withstand very high pressures.
3. Recycling plastic avoids about 25% of emissions of CO² compared to that generated during production of raw plastic (D'Ambriere, 2019).
4. More jobs associated with a recycling plant than a landfill, incineration, or petrochemical industry synthesis of virgin resins (D'Ambriere, 2019). It supports local industry, and supports independence of economy in countries with few oil or gas resources.
5. Products can only be recycled economically if
 - (1) recycling is built into their design,
 - (2) there are sufficient quantities in waste streams,
 - (3) manufacturer can meet the technical challenges involved in increasing the amount of recycled materials in their products,
 - (4) no problematic odor or color.

Circularization of Plastics – Recycling

Not really a circular economy – feedstock for durable plastics.

1. Many products are composed of different types of plastic and sometimes non-plastic components – contaminated. **TerraCycle** works with brands, retailers, and manufacturers to create new product designs and packaging that can be recycled because not contaminated. TerraCycle launched **Loop**: Pilot program consumers can purchase at select Kroger's stores and return the food and product containers durable, reusable, or fully recyclable back to the vendor.
2. Plastic production and application is continually expanding, but the lifetime of plastic products is typically short. New plastic introduced by DOE LBNL
3. There are many different types of plastics, with widely different properties, that can make recycling problematic.
4. Plastics can only be reused a limited number of times before they are too degraded for further use. E.G., reprocessing of PET polymer leads to discoloration and change in polymer properties of elasticity, strength, barrier.
5. New applications must be selected according to new color and properties. Properties of a polymer can change over time resulting in inferior mechanical properties and/or processing behavior compared to virgin material.

Incineration of Plastics

Incineration of plastics is monetized (EU burns almost 42% of its waste, US burns 12.5%: National Geographic), but emit toxic pollutants (e.g., dioxins, acid gases, heavy metals) and operation of scrubbers is not enforced. (www.epa.gov/air-emissions-monitoring-knowledge-base/monitoring-control-technique-wet-scrubber-gaseous-control)

Gasification melts plastics at very high temperatures in near absence of O^2 so toxins are not formed, and generates synthetic gas that is **not** competitive with natural gas. Many more plants in Asia and Australia.

Pyrolysis melts plastics at lower temperatures than gasification and with less O^2 , and can be refined to diesel fuel and other petrochemical products *including new plastics*. Seven small pyrolysis plants now operating in US. Reportedly produces no harmful pollutants except “a minimal amount of carbon dioxide” (Bakaya, founder of Renewology), but not all companies have met the pollution control limits.

Landfills



Engineered areas of land for the controlled deposit of solid waste.

MSW **landfills** comply with *Resource Conservation and Recovery Act (RCRA)*, including siting restrictions in floodplains, surface/groundwater protection, disease and vector control, open-burning prohibitions, explosive gas (methane) control, fire prevention through the use of cover materials, and prevention of bird hazards to aircraft.

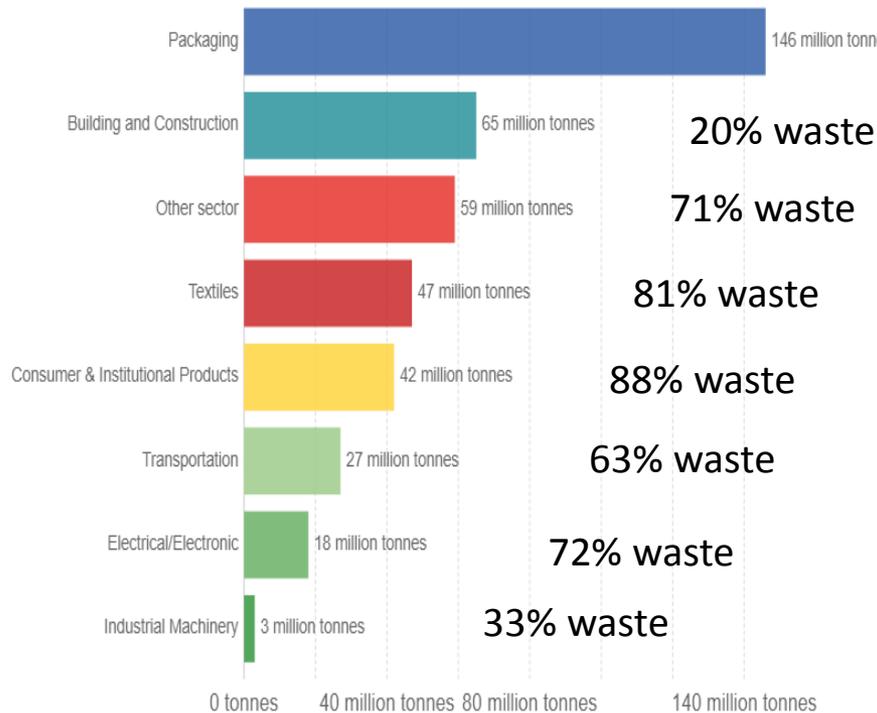
After adoption of the first RCRA in 1968, the total # of **landfills** in the U.S. steadily declined. Despite the diminishing percentage of total MSW disposed of in **landfills**, the total waste capacity of landfills is still increasing.

Landfill gas can be utilized by a gas turbine producing electricity or pipeline-grade gas from methane piped from a large **landfill**.

Global production and waste (2015)

Primary plastic production by industrial sector, 2015

Primary global plastic production by industrial sector allocation, measured in tonnes per year.

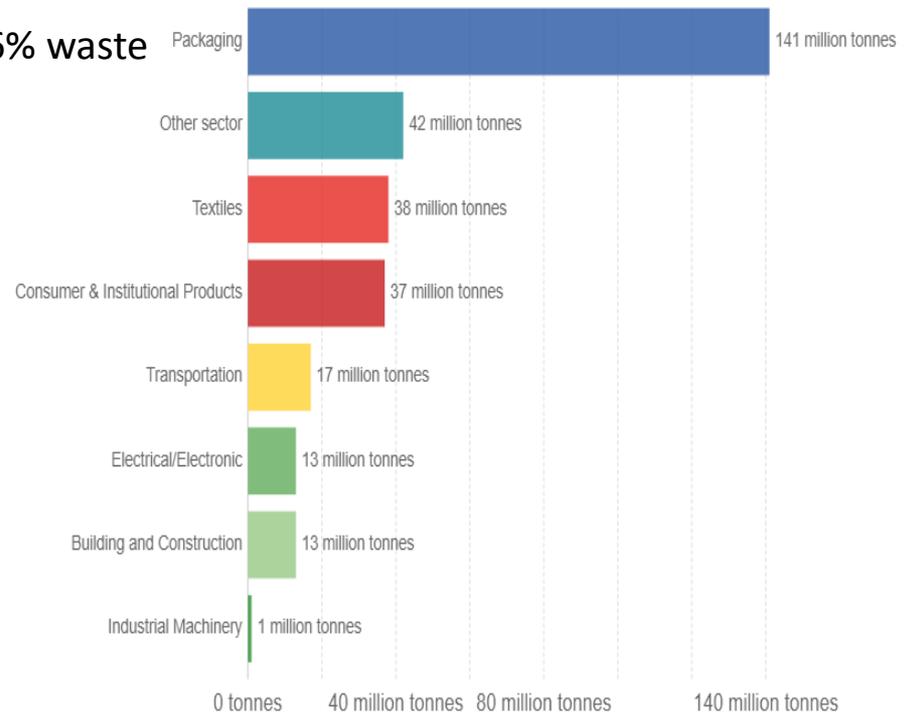


Source: Geyer et al. (2017)

CC BY-SA

Plastic waste generation by industrial sector, 2015

Global plastic waste generation by industrial sector, measured in tonnes per year.



Source: Geyer et al. (2017)

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Individual Actions

Refuse, Reduce

- Look for products that use less or no packaging.
- Store, freeze, and heat food in glass rather than plastic – *for your health.*



Plastic wrapping is the largest use of plastic. You can do something!

Individual Actions

Refuse, Reduce



- Choose reusable wrappers - bees wax wraps and glass containers.
- Eat in at restaurants instead of taking out.
- Take reusable container to restaurants for leftovers!
- Make use of bulk bins at grocery stores and bring your own containers.
- Avoid products with microbeads. If polyethylene or polypropylene on label, has microbeads.
- Use reusable cloth bag when shopping.
- Say no to plastic straws. #stopsucking (Strawless Ocean Initiative of Lonely Whale (501 (c) 3)

Can You Cook a Plastic-Free Meal? (NOAA MDP)

- Did your cereal and milk come in plastic waste cereal bag and milk jug? Was your fruit in a plastic bag or container? Were the coffee grounds in a plastic bag?
- So much of our food is covered in plastic, having a meal with only ingredients not found in plastic packaging can be a real challenge, but not impossible. You can also *reduce* the amount of plastic when shopping.
- Challenge yourself to make your own plastic-free meal.
 - Go the butcher and ask for meat in butcher paper instead of plastic.
 - Bring your own produce bags and not use any plastic.
 - Buy in bulk with your own container.
 - Make your own food, such as granola and granola bars.
 - Challenge yourself to make at least one plastic-free meal/week. Share with others



Individual Action

Reduce, Recycle

- Plan ahead - fill water at the tap.
- Use reusable drinking water bottles made of stainless steel, not plastic.
- Reuse and recycle single-use plastics.
- Encourage others. Teach by sharing your story.
- *Events – set example for no single use plastics*
- *Use it forever.*



Mind Your Clothes!

- Clothing made from plastic such as nylon, polyester, rayon, acrylic and spandex, shed hundreds to thousands of microfibers with each wash.
- Fleece and other synthetic fabrics – *wash less often*. Use microplastic catching bags. (Ex. Patagonia guppy bag friend that catches microplastics in wash)

Researchers from the University of California Santa Barbara's Bren School of Environmental Science & Management found that when synthetic jackets are washed, on average 1,174 milligrams of microfibers are released from the washing machine. These microfibers then travel to local wastewater treatment plant, where up to 40% of them can enter rivers, lakes, and oceans (depending on local wastewater treatment conditions).



Individual Actions

Reuse

- Buy used.
- Buy reusable over disposable items.
- Maintain and repair products.
- Borrow, rent or share items.
- Try to use something longer.

Break the bond of trending fashion and planned obsolescence.

We are never more than three feet away from something plastic.



Susan Freinkel, 2011

Individual Actions

Recycle

- Close lid on trash and recycle bins.
- Don't litter.
- Pick up litter, the smallest are most likely to be eaten by aquatic wildlife due to scarcity of food in the aquatic environments. Aquatic environments are declining at a much faster rate than terrestrial ecosystems. (National Geographic)
- Look for products made from recycled plastic materials.



Marsh Creek PA



Acadia National Park ME

Community Actions

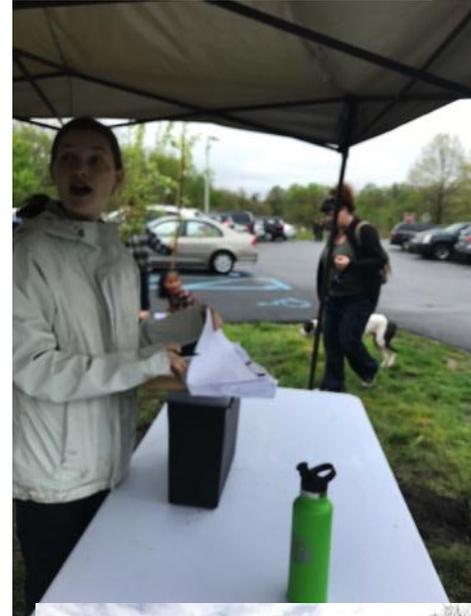
NOAA Marine Debris Clearinghouse



- If you want to know more about studies being funded by NOAA that are experimental or naturalistic, visit:
<https://clearinghouse.marinedebris.noaa.gov/>
- Participate in the annual International Marine Debris Coastal Cleanup, organized by the Ocean Conservancy, every September. Resulting data goes to NOAA and international groups to track plastics where you live and around the world
- Participate in your local watershed, wildlife refuge, and other environmental debris clean-up actions.

Community Action

- Organize and schedule community clean ups.
- Urge your favorite restaurants to use reusable or compostable ware and packaging.
- Work with your municipality to offer recycling events and to encourage businesses to reduce single use plastics.
- Work with your local watershed groups to conduct citizen science research on local streams – *more on this*.
- Educate others about plastic pollution and solutions. Inspire by example!



Community Action

- Educate students and teachers to become trash free.
- Goals: Reduce littering behavior by understanding their local watershed, recognizing the impacts of their waste and litter, and empowering them to be student leaders on debris prevention
- The Alice Ferguson Foundation in NJ works with 6th-12th grade students:
 - Multiple classroom visits
 - Student-led action projects
 - Peer-to-peer mentorship program with local elementary school students



Students in Prince George's County, MD learn about the watershed they are a part of (Photo Credit: Alice Ferguson Foundation)

Technologies

Urban stream plastic and debris removal

- Baltimore's Trash Wheel system: Collects trash before reaching open waters of Baltimore Harbor and Chesapeake Bay
- 14 foot steel water wheel powered by river current, that uses a rake and conveyor system that pulls floating litter and debris and deposits into a dumpster barge. Has an array of 30 solar panels to power the water pumps so machine operates when current is slow. During a large rainstorm the two systems work in tandem to power the machine to collect anything that floats from a single cig. butt to a tree. Funded by Maryland Port Administration and a subsidiary of Exelon (Constellation). Dept. of Public Works helps pay for ongoing operation with stormwater remediation fee established by state law in 2012.

Journal of Ocean Technology: Baltimore's Mr. Trash Wheel



Baltimore's Mr. Trash Wheel is the first of its kind in the world. It is a 14-foot diameter steel water wheel that uses a rake and conveyor system to collect floating debris and deposit it into a dumpster barge. The wheel is powered by a 30-kilowatt solar array and a 10-horsepower motor. It is operated by the Baltimore Department of Public Works. Copyright Journal of Ocean Technology 2016.

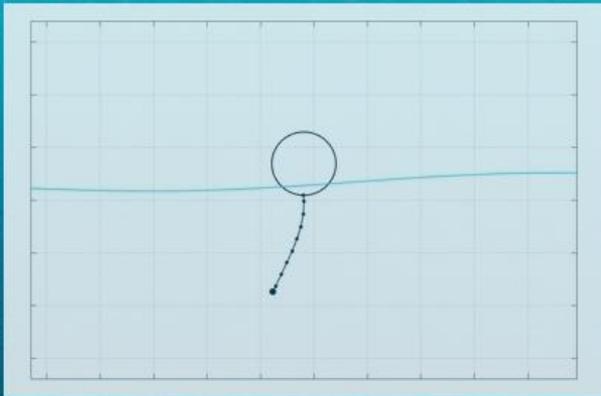
Baltimore's Mr. Trash Wheel

By Adam Lindquist, Director of the Healthy Harbor Initiative

Waterfront Partnership of Baltimore

Emerging Technologies

1. FLOATER



Floating for years in the garbage patch

Concentrates plastic just beneath surface of the ocean gyre, and remove it by support vessel. Uses 600 m long floater and 3 m deep skirt below.

<https://www.theoceancleanup.com/>

TAKE ADVANTAGE OF NATURAL OCEANIC FORCES

Both the plastic and system are being carried by the current. However, wind and waves only propel the system, as the floater partly sticks above the surface, while plastic is primarily just beneath it. The system thus moves faster than the plastic, allowing the plastic to be captured.



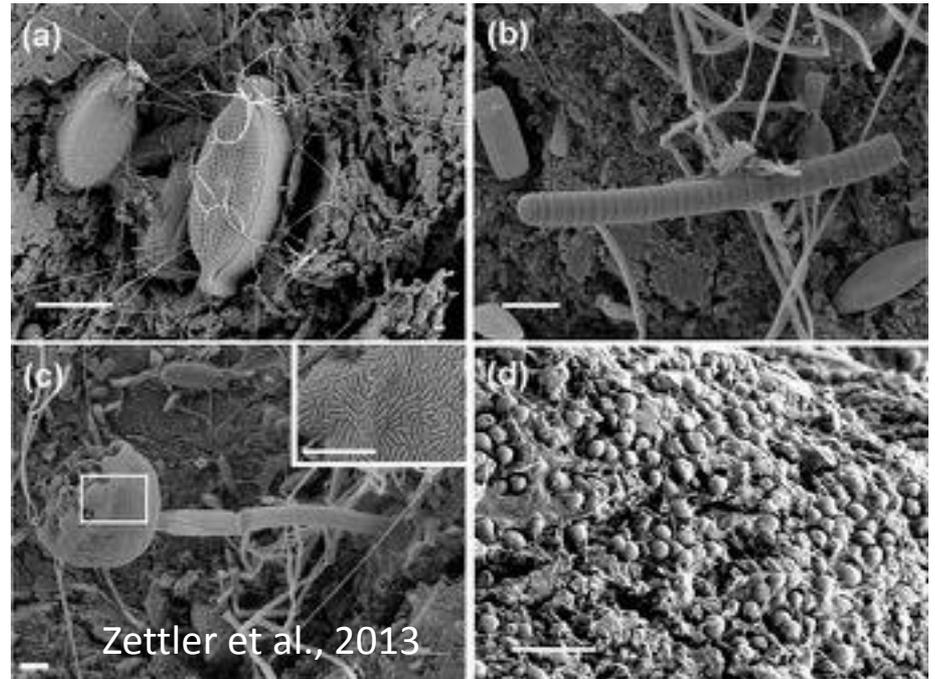
Emerging Science

Plastic marine debris provides an artificial hard substrate for microbes – termed a Plastisphere (Zettler et al. 2013).

Plastisphere communities are a diverse microbial community.

Distinct from surrounding surface water, as such they are a novel ecological habitat in the open ocean.

Future research needed to understand biodegradation of microorganisms and enzymes in seawater and sediment, with hopes to develop innovative bioremediation processes for waters contaminated by plastics.



The identification of several hydrocarbon-degrading bacteria suggest microbes might play an important role in degrading plastic marine debris.

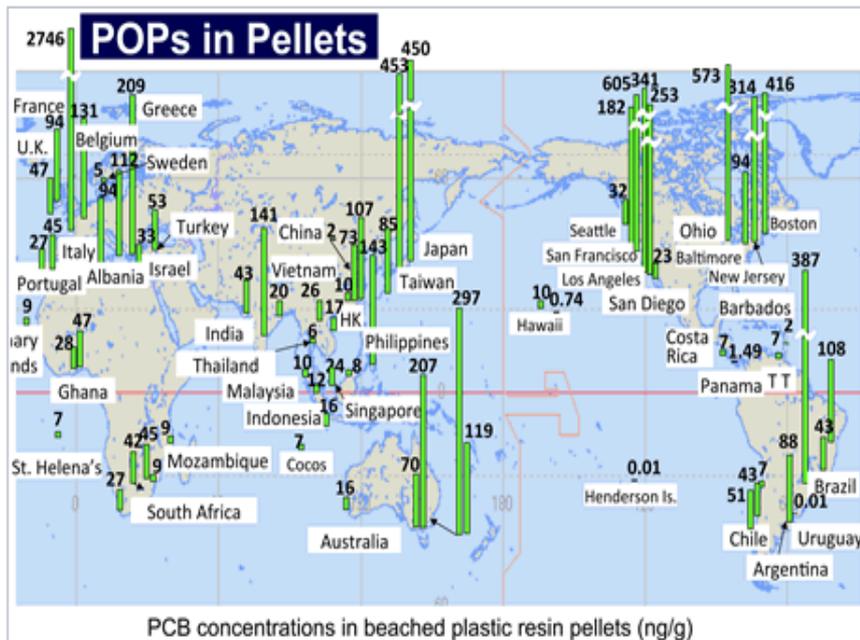
Individual Action

Join International Pellet Watch

International Pellet Watch

Global Monitoring of POPs using Beached Plastic Resin Pellets.

POPs are persistent organic pollutants that adsorb to plastics.



What's International Pellet Watch (IPW)

Global monitoring of POPs by using beached plastic resin pellets.

IPW is a volunteer-based global monitoring program designed to monitor the pollution status of the oceans. Since its launch in 2005, ~ 80 groups and individuals from ~ 50 countries have been participating...

[more](#)

Plastic Pollution.

IPW is based on the fact that POPs are accumulated in resin pellets (plastic raw material) from the surrounding seawater by a factor of millions. Similar accumulation occurs with broken plastic fragments...

New Plastic Products

- Biodegradable plastics can be but are very rarely recycled, are usually incinerated, and often end up in landfills. They are supposed to biodegrade naturally.
- Landfills do not contain the conditions needed (moisture, oxygen) for composting/biodegrading
- Fossil fuel plastics use CO_2 captured long ago and buried. Bio-based plastics use recently captured CO_2 and will be captured again when new bio-based plastic are produced. Therefore, fossil fuel plastics contribute to net increase of CO_2 , not biodegradable plastics.
- However, research about biodegradable and compostable products in landfills indicate that they are releasing methane as they break down.
- Compostable plastic products require a specific setting in order to break down. Commercial facilities can compost these new products with high temperatures, air flow, and moisture.
- Lawrence Berkeley National Laboratory reports in 2019 making a new plastic that can be recycled again and again, back into its original monomers, from mixed waste streams with additives present, into same product or new materials of any color, shape or form. PDKs-poly(diketoenamine)s

Thank you

Questions or comments are welcome



Plastic recycling numbers



- 1 – PETE, polyethylene terephthalate
- 2 – HDPE, high density polyethylene
- 3 – PVC, polyvinyl chloride
- 4 – LDPE, low density polyethylene
- 5 – PP, polypropylene (most common type found in water)
- 6 – PS, polystyrene
- 7 - Other

Some Dumping FAQ – Supplementary – not to show

By Bekah Barlow

Did you know that it's *legal* to dump trash in the ocean? Yes, there are limitations for what you can and cannot dump. But it is perfectly acceptable to dump your raw sewage, paper, rags, glass, metal, bottles, or similar refuse, as long as you are at least 12 miles away from the nearest shoreline. It is not permissible to dump plastics anywhere.

[Learn](#) the regulations are for proper garbage disposal at sea.

JUST HOW LONG WILL YOUR TRASH LAST AT SEA?

* Quoted in U.S National Park Service; Mote Marine Lab, FL and "Garbage In, Garbage Out," Audobon Magazine, Spt/Oct 1998. from "Pocket Guide to Marine Debris," The Ocean Conservancy, 2004

When it comes to cruise ships, this trash can add up. An average-sized cruise ship would house 3,000 passengers and crew. The largest cruise ships can have up to 5,000 passengers and crew. Of these cruise ships:

- One average-sized cruise ship dumps about 30,000 gallons of human waste into the oceans each day. If that cruise ship is within three miles of a U.S. shoreline, the sewage must be treated, but if they are outside of three miles, they can dump raw, untreated sewage into the oceans.
- In addition to the 30,000 gallons of sewage, each cruise ship dumps, on average, 255,000 gallons of gray water per day. Gray water includes water used for showers, laundry services, and dishwashing, and will contain soap and chemicals, even toxic chemicals used for photo-processing and dry-cleaning!
- An average cruise ship will produce seven tons of garbage and solid waste *every day!* In a year, approximately 15 billion pounds of garbage is dumped into the oceans.
- The pollution produced by the emissions of one cruise ship in one day equals that of about 12,000 automobiles.

Paper towel	2-4 weeks
Orange or banana peel	2-5 weeks
Newspaper	6 weeks
Apple core	2 months
Waxed milk carton	3 months
Plywood	1-3 years
Wool sock	1-5 years
Cigarette filter	1-50 years
Plastic Bag	(at least) 10-20 years
Plastic film canister	20-30 years
Nylon Fabric	30-40 years
Leather	50 years
Tin can	50 years
Foamed plastic cup	50 years
Rubber boat sole	50-80 years
Foamed plastic buoy	80 years
Aluminum can	80-200 years
Disposable diapers	450 years
Plastic beverage bottles	450 years
Monofilament fishing line	600 years
Glass Bottle	1,000,000 years

Areas of Needed Research

- Assess microplastics' impact on ecological systems and food safety and improve understanding of potential toxicological mechanisms and public health effects.
- Identify, if possible, lower risk species, production methods, or regions, and interactions of microplastics with nutrients and various seafood processing and cooking methods, to promote adjustments rather than consumer avoidance of seafood.
- Standardize data collection methods for microplastic occurrence in the environment and food stuffs
- Assess exposure risk for dietary intake.
- Measure how plastics are absorbed by different animal tissues.
- Plant absorption?
- Collect data on presence, identity, and quantity of degraded plastic in food.
- Observe the translocation of microplastics through aquatic food and human food system.
- Collect toxicity exposure data evaluating mixtures of various additives/monomers.
- Collect toxicological data on the most common polymers and their relative contributions to microplastic contamination.
- Develop specific biomonitoring processes and body burden measurements for additives and monomers.
- Research toxicokinetics and toxicity of micro- and nanoplastics and their associated chemical compounds, to determine local gastrointestinal (GI) tract effects in animals and humans.