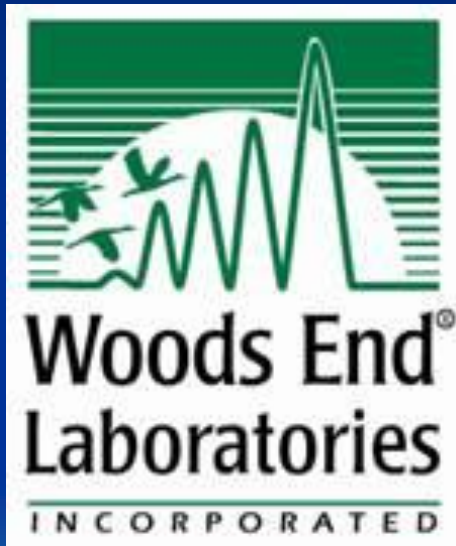


Should Plastic-Coated Paper Products be Allowed in Materials Collected for Composting ?



Overview

Recent research shows:

- Many US compost collection programs accept plastic-coated paper products.
- When composted, these products produce plastic fragments that do not biodegrade.
- Plastic fragments can make their way from compost-treated soils into the larger environment, and may be ingested by living organisms.
- Plastics fragments accumulate persistent organic pollutants and can transfer these chemicals to living organisms.



Reaching Zero Waste

=

**Increasing the amount of
organic material diverted from
the waste stream**

US Compost Collection Programs



According to the January 2015 issue of BioCycle:

- 198 programs in the US have residential food waste collections (up from 95 in 2009)
- 2.74 million households served

According to further investigations by Eco-Cycle:

- Over half of these programs do not accept plastic-coated paper products



Plastic-Coated Paper Products

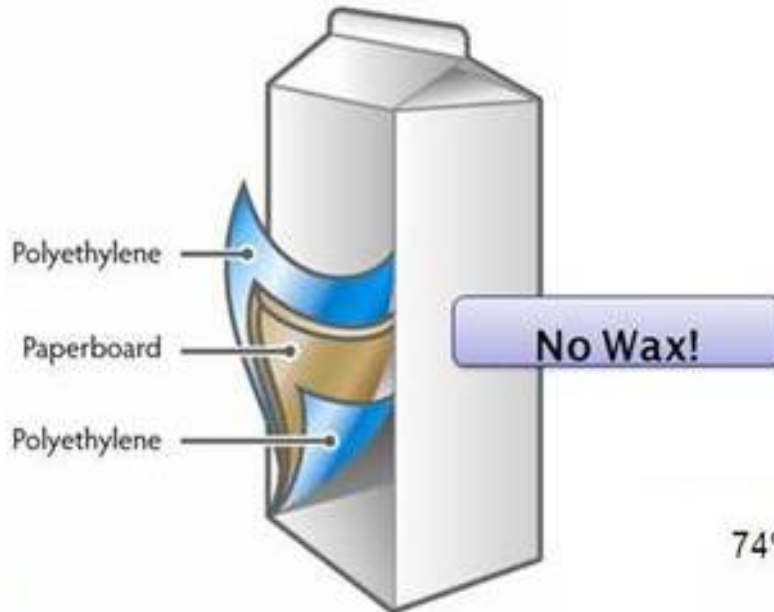


Many organics collection programs in the US allow:

- milk and juice cartons
- hot and cold paper drinking cups
- paper plates (some clay, some PE)
- frozen food containers
- plastic-lined paper bags
- take-out containers

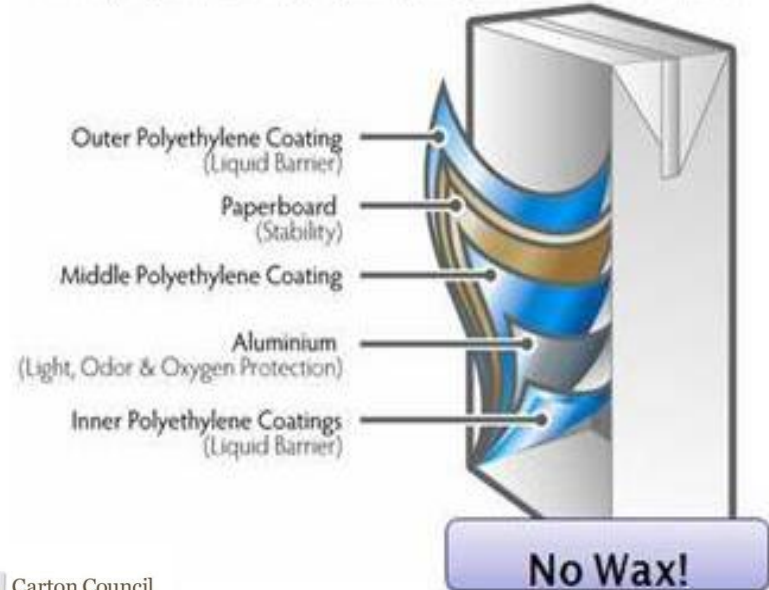


Refrigerated cartons contain about 80% paper and 20% polyethylene.



Composition of Cartons

Shelf-stable cartons contain on average 74% paper, 22% polyethylene and 4% aluminum



Polyethylene (PE)
is present in both
refrigerated and
shelf-stable cartons

Petroleum-Based Plastic is Not Biodegradable

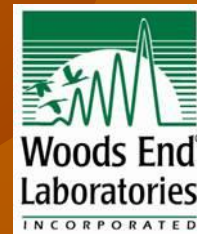
- Most plastic-coated paper products are coated with polyethylene (LDPE)
- PE has not been shown to biodegrade in reasonable time
- PE (pellet or film) is the standard “negative control” in the ASTM 6400 test to determine compostability of any product



Plastic coating from freezer box after 1 year in backyard compost

Testing by Woods End Laboratories

- Woods End Laboratories is a Biodegradable Products Institute (BPI) approved ASTM D6400 test facility
- Employed ASTM D 6400 §6.2 : product disintegration to less than 10% @ 2mm in 12 weeks.
- Study extended to 180 days
- Employed ASTM D 5338 “Test Method for Determining Aerobic Biodegradation of Plastic Materials under Controlled Composting Conditions” (a subset of ASTM D 6400 compost biodegradability tests)



Materials Examined

Criteria for tested product packages:

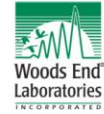
- coatings that are typical in the food packaging industry
- often included in compost collection programs
- commonly available to the consumer

Sample Name	Type of Paper Product	Coating *
1 Tropicana	Carton, Juice	LDPE + Other Resins
2 Nesquik	Carton, Milk	LDPE
3 Minute Maid	Carton, Juice	LDPE + Nylon or Ethyl Vinyl Alcohol
4 Dixie	Paper Cold Cup	LDPE
5 Dixie	Paper Plates	80% Clay, 20% Acrylic
6 Walgreens	Paper Cold Cup	LDPE
7 Walgreens	Paper Plates	Kaolin, Synthetic Latex, Calcium Carbonate
8 Stouffer's	Ovenable Tray	PET
9 Stouffer's	Freezer Paperboard	LDPE
10 Food Boat	Food Boat	Clay
11 Control	Printer Paper	None

Information on the composition of the coatings listed above was obtained through interviews with paperstock and product manufacturers by Eco-Cycle, Inc.

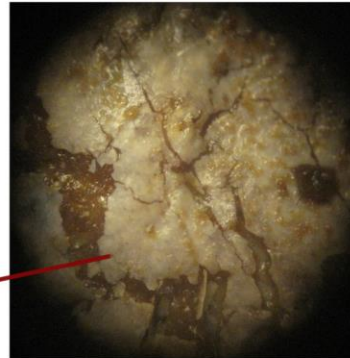
30x digital microscopy of peeling and fragmenting process

Microscopic Images After 5 Weeks of Biodegradation



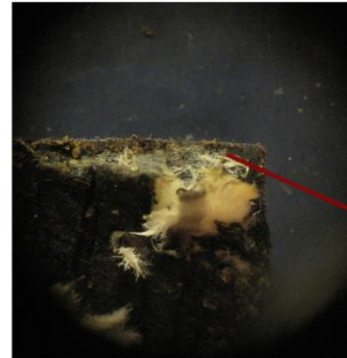
Food Boats/Clay

Natural clay material disintegrating normally.



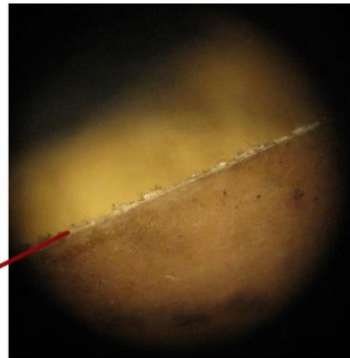
Stouffer's Tray/PET

Inside paper layer (now soft & pulpy) against black coated, intact plastic layer (no degradation).



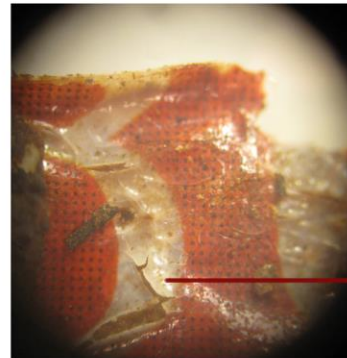
Minute Maid/LDPE & Nylon

Some delamination. Sharp, intact plastic edge. No visible signs of degradation.



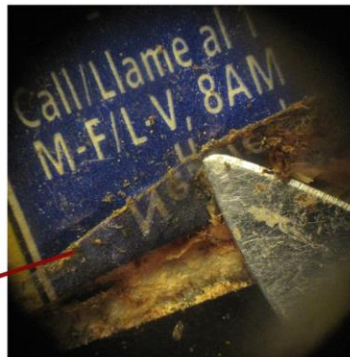
Stouffer's Box/LDPE

Plastic layer cracking and peeling away from ink layer. No obvious degradation.



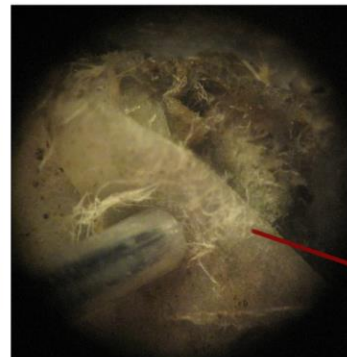
Nesquik/LDPE

Intact plastic layer (no degradation) being peeled back from inside paper layer (soft & pulpy).



Tropicana/LDPE Blend

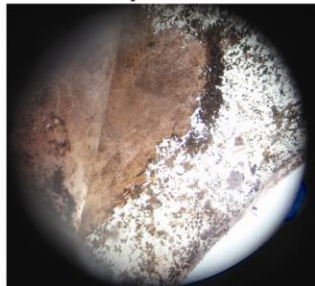
Intact plastic layer being peeled away from paper layer (now soft & pulpy).



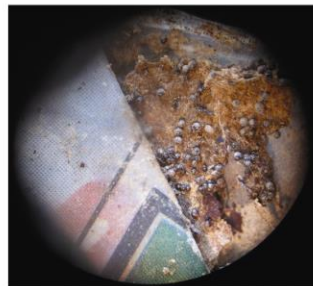
Residual Fragments in Compost at 30-100x

2mm

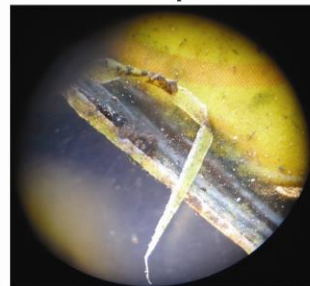
Tropicana



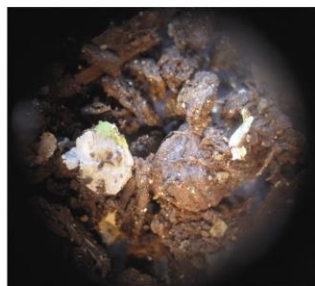
Minute Maid



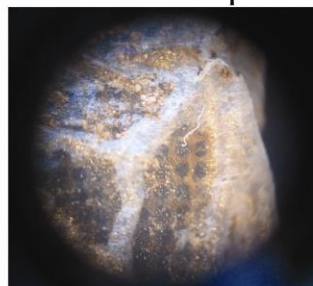
Nesquik



Dixie Plate



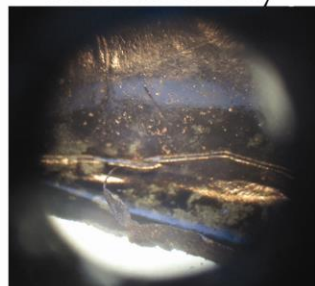
Dixie Cup



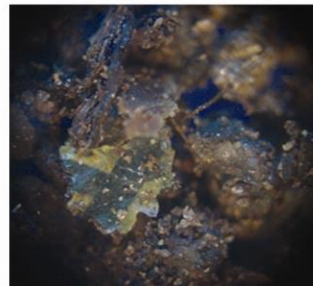
Walgreens Cup



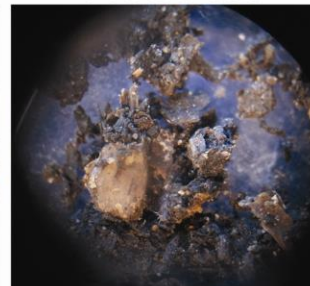
Stouffer's Tray



Stouffer's Box



Food Boat

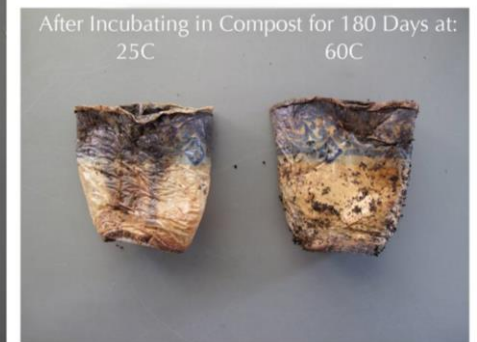


Conclusions

- Plastic coatings did not biodegrade.
- Coatings retarded the biodegradation of the paper layer.
- When coated on both sides, little degradation occurred.
- Micro-plastic fragments were shed from all of the plastic-coated samples, *including* those that remained largely intact due to double-sided coatings.

Milk Carton Juice Carton Paper Cup

PE coatings on both sides of paperstock almost entirely inhibited the biodegradation process.



Paper Plates



Before and After 180 days of composting at 25°C and 60°C

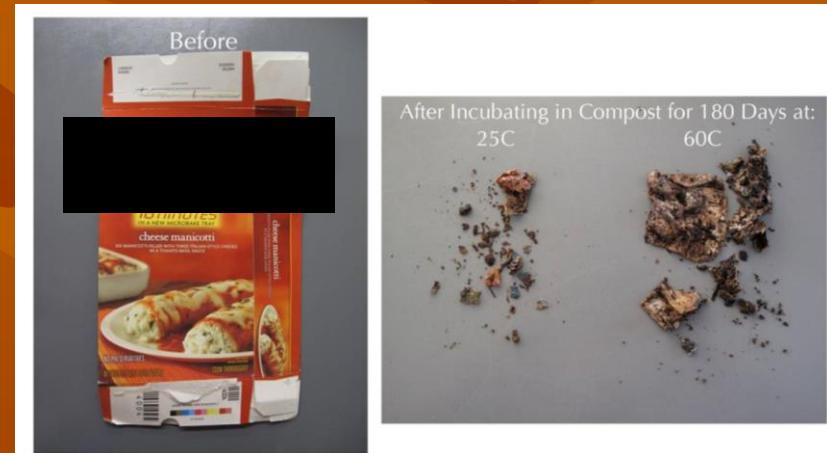
- Usually clay-coated. One sample contained 20% acrylic mixed with the clay. Acrylic fibers were evident in finished compost.
- Approximately 10% (according to industry sources) are coated with PE, and would be expected to shed micro-plastics in the same way as other PE-coated samples.

Freezer Box

Oven-able Tray

- Freezer box (single-LDPE coated) almost passed disintegration test at 58°C and did pass at 25°C
- Material likely to pass through screen and end up as visible plastic contaminant in compost

• Oven-able tray is double-PET coated and likely to be screened out as an entire fraction



Further Findings

- Obvious delaminating took place. The plastic-coating layers, originally injected into the paperboard, began to separate off of the carrier material.
- Some coatings were brittle, and therefore caused fragmentation. Others were less so.
- Plastic fragments smaller than $\frac{1}{2}$ inch (about 12mm) remaining after 12 weeks would likely pass through into the final compost. Composters do not generally sieve finer than this. At best, under suited, dry conditions, a $\frac{3}{8}$ inch (9mm) sieve may be used.

Delamination Process



- Peeling and delamination during non-agitated composting
- Turning machines may exacerbate peeling and fragmentation
- Composting concentrates non-degradables

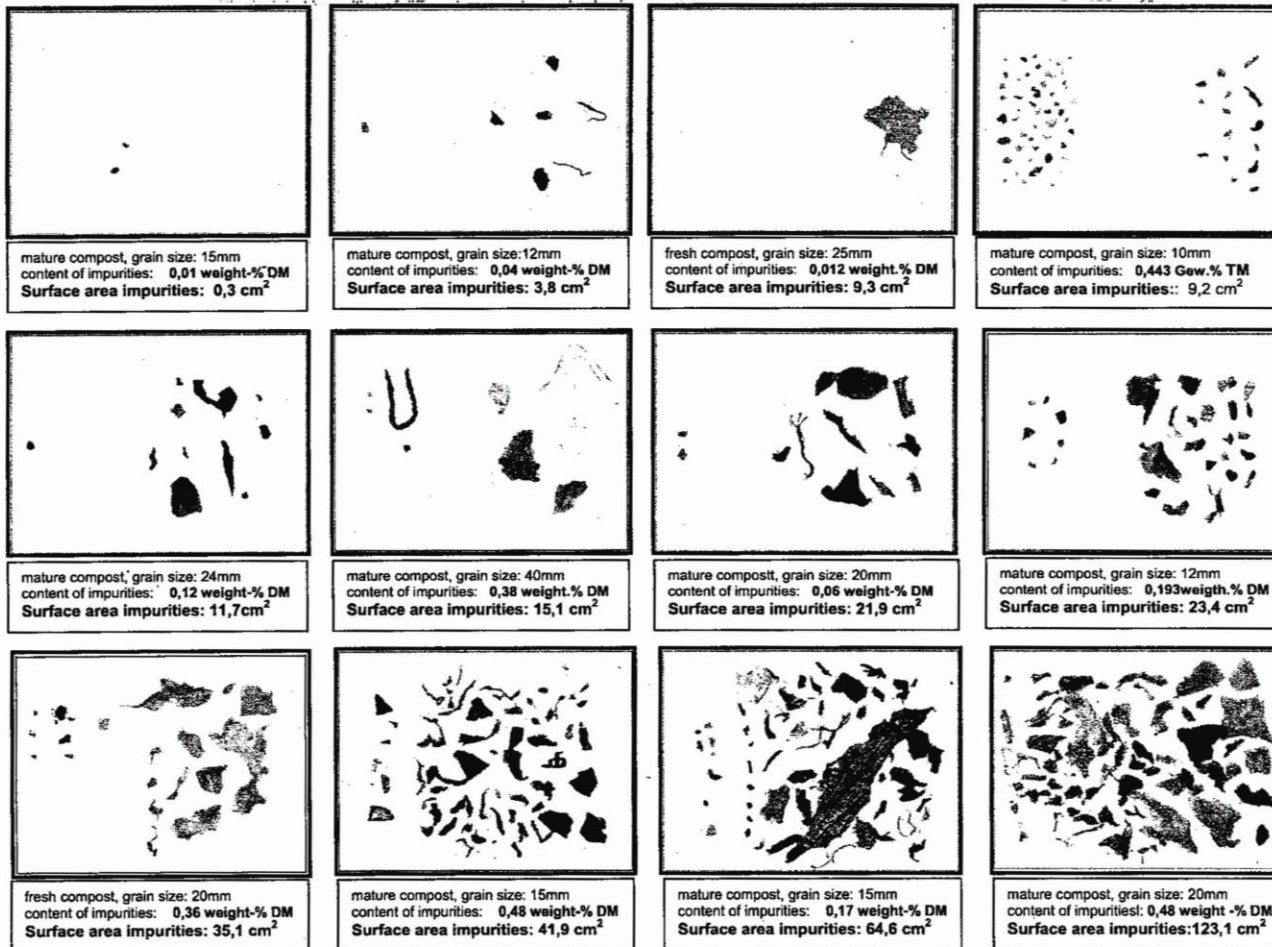
Household Food Scrap Collection

- Cartons, coated cups and trays *are not made to be composted*
- 20% of a carton is PE
- Many programs accept cartons with food scraps
- Each half gallon carton (pictured) has ~15g of pure PE
- 15g of PE in ~1.5kg food scraps per carton = a potential 0.01% of PE in compost



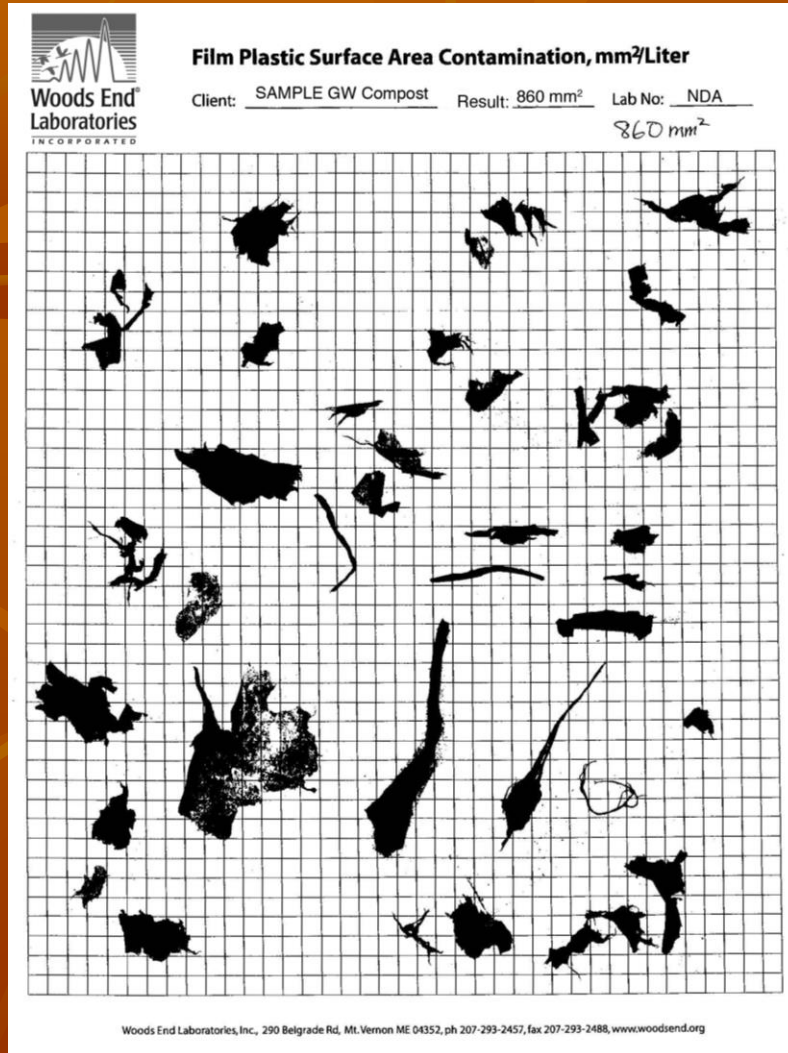
Visual Scale of Plastic Contamination in Composts all containing less than 0.5% foreign matter

Example of scanning finished compost for non-degraded plastic residues that have high surface area relative to weight (SA:W). All samples chosen had < 0.5% plastic by weight.



Reference: Thelen-Juengling, M (2006) New Method for evaluation of impurities in compost. ORBIT, Weimar

New EU Standard Requires Quantifying Surface Area (SA) by Scanning Plastic >2mm in Composts



This sample exceeds the EU clean compost standard of 800 mm² SA/liter compost.

800 mm² SA/liter =
35 sq. inches per cubic foot
compost

15g PE from carton
after delaminating
would be as much as
387 sq. inches of
plastic per cu. ft.

< 0.1% by weight in green-collection composts

Source: Woods End Laboratories

Economics –

Non-Compostables Increase Processing Costs

	<u>Per Ton Cost</u>
Transport to Facility	\$10
Grinding/Mixing	\$4
Active Composting	\$20
Screening	\$2
Transport to Landfill	\$10
Landfill Cost	<u>\$85</u>
Cost per Ton to Process Non-Compostables	\$131
Revenue per Ton (av. tip fee)	\$40
Loss per Ton (including Loss of Product Sale \$9)	\$100

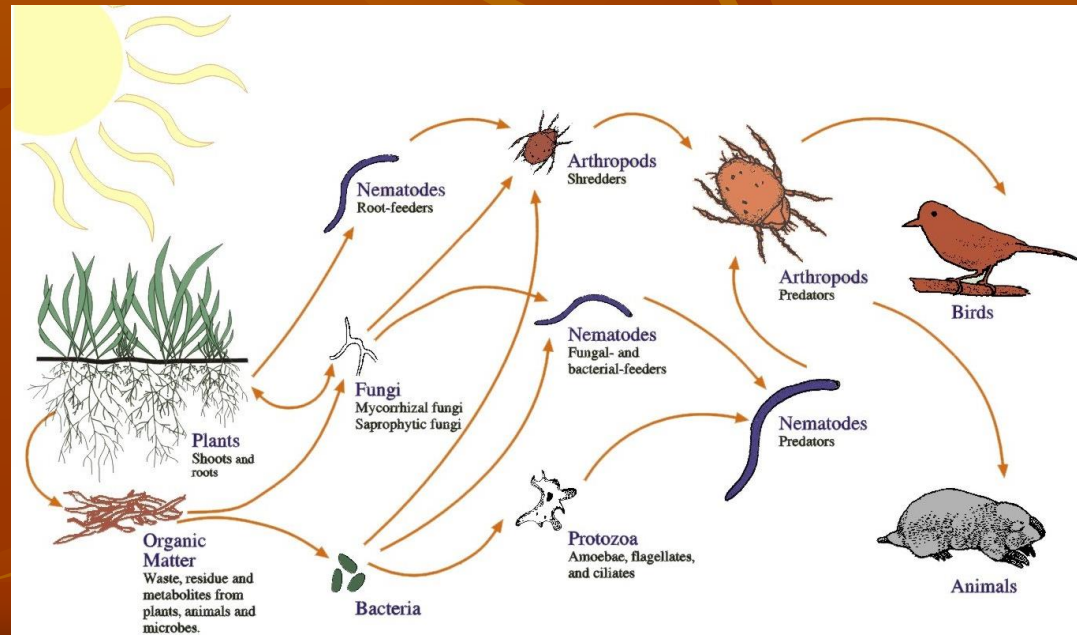
From Compost to the Environment

“There is good evidence that both the **micro and macro-plastic fragments** found in compost applied to the soil will exacerbate the problem [of plastic pollution] as [the fragments] are carried by wind and surface run-off into stream and river waters, and eventually into marine environments.”
(Page & Leonard, 2002)





What consequences do the plastic fragments have for ecosystems and human health?



The detrimental effects of macro-plastics on wildlife are well documented, particularly in aquatic environments.



Seal entangled in plastic Photographer unknown



Albatross chick ingesting plastic

[Jeanne Gallagher] photographer, Cynthia Vanderlip

Snapping turtle deformed by plastic

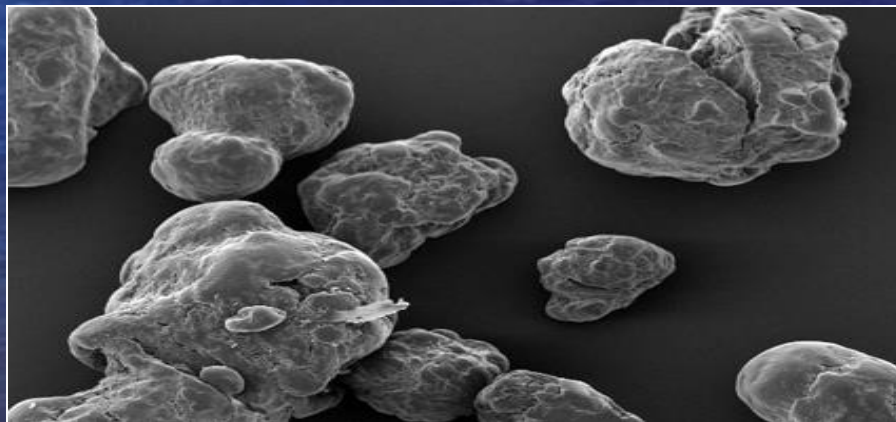


**Including:
Suffocation
Entanglement
Starvation**



[Jeanne Gallagher] Courtesy of Algalita Marine Research Foundation

“Plastic debris is accumulating in terrestrial and aquatic habitats worldwide. This debris is progressively fragmenting into smaller pieces... The abundance in the water column has increased considerably over the last 40 years, and this trend mirrors the global rise in plastic production.” (Browne, Galloway & Thompson, 2009)



Microscopic plastic particles

Plastics Fragments Ingested by Marine Organisms

Salp ingestion of plastic



[Jeanne Gallagher] Courtesy of Algalita Marine Research Foundation



Microplastic in the digestive tract of an amphipod

“...studies have demonstrated that microplastics are ingested by a large variety of marine taxa...including birds, mammals, fish and invertebrates...microplastics can be passed through the food web as predators consume prey.” (GESAMP 2015)

... filter-feeding animals, such as mucous web feeding jellies and salps, were...heavily impacted by plastic fragments... Filter feeders are at the lower end of the food chain, ...fifty species of fish and many turtles are known to eat them... accumulating plastic in their stomachs.” (Tamanaha & Moore, 2007)

Study by Browne, Dissanayake, Galloway, Lowe & Thompson (2008):



Micro-plastics translocated from the gut to the hemolymph of a species of mussel (*Mytilus edulis*) persisted for over 48 days

Predators of mussels:

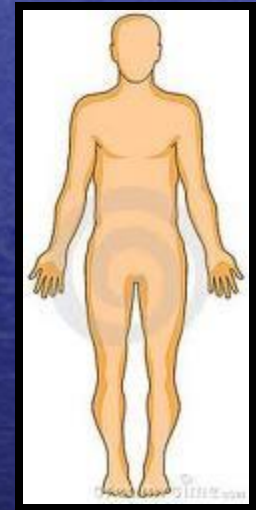
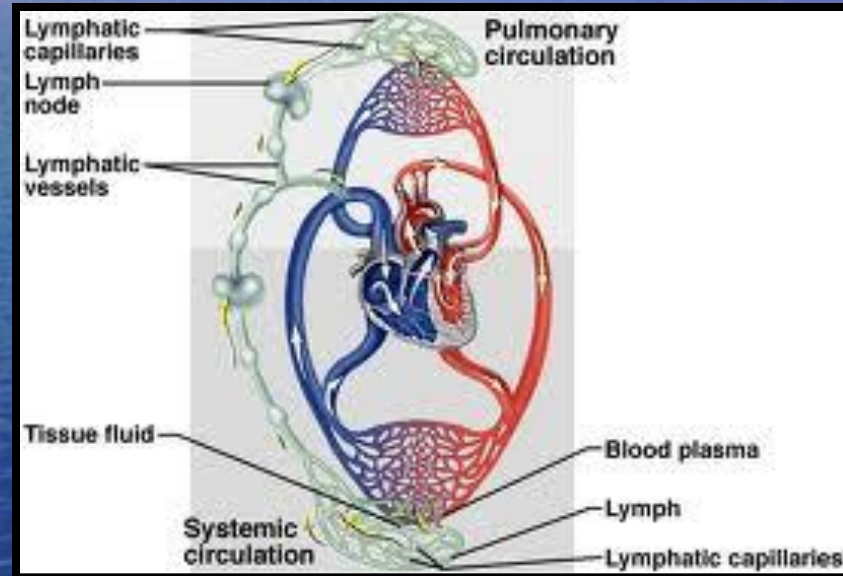
- birds
- crabs
- starfish
- predatory whelks
- ***humans***



Relatively high concentrations of microplastics were detected in Belgian commercially grown mussels and oysters...As a result, the annual dietary exposure for European shellfish consumers can amount to 11,000 microplastics per year. (GESAMP, 2015)

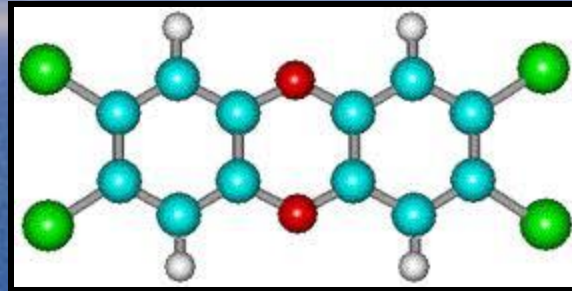


Micro-particles of plastic



“When humans or rodents ingest microplastics they have been shown to translocate from the gut to the lymph and circulatory systems ...adverse effects may start to emerge due to particle interactions with cells and tissues...these include deleterious effects at the cellular level...Human exposure is also of concern if seafood containing microplastics is consumed” (GESAMP, 2015)

Plastic Fragments Concentrate Persistent Organic Pollutants (POPs), transferring them around the globe and into living organisms.



“... plastic has been shown to adsorb and concentrate hydrophobic contaminants, including polychlorinated biphenyls, dichlorodiphenyl trichloroethane, and nonylphenol, from the marine environment at concentrations several orders of magnitude higher than those of the surrounding seawater.” (Mato et al., 2001)

“If plastics are ingested, they could act as a mechanism facilitating the transport of chemicals to wildlife. This may be particularly relevant for microplastics since they will have a much greater ratio of surface area to volume than larger items...” (Browne et. al., 2009)



“...calculations and experimental observations consistently show that polyethylene (PE) accumulates more organic contaminants than other plastics such as polypropylene (PP) and polyvinyl chloride (PVC).” (Teuten et. al., 2009)



More research needs to be done to see how micro-plastics affect soil and freshwater ecosystems.



"...soil is quite different from oceans, but soil also contains many features of an aquatic ecosystem...Thus some of the same principals apply...Microplastic could be ingested by micro- and mesofauna... and thus accumulate in the soil detrital food web...In addition, microplastics could alter physical properties of the soil... Once in the soil, these particles may persist, accumulate, and eventually reach levels that can affect the functioning and biodiversity of the soil and terrestrial ecosystems." Rillig, 2015

Once plastic fragments are dispersed into the greater environment, they are impossible to recover.

Our conclusion: policies and practices that ensure that plastic-coated paper products do not enter the compost stream must be put into place if compost operations are to remain an environmentally sound alternative to landfilling.

The Precautionary Principle

- “When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically”
(source: <http://www.sehn.org/state.html#w>)
- Referenced in UN and EU treaties and protocols since the 1990s
- Adopted by several US communities throughout the 2000s
- Applied to fields such as nanotechnology, GMOs, threats to biodiversity and the introduction of new chemicals
- Questions if the harm is necessary, if benefits outweigh potential risks and if better alternatives exist.

Better Alternatives

- New recycling markets for cartons
- Coatings for paper products that are truly compostable
- Use durables instead

Our recommendation:

- Include plastic-coated products on lists of prohibited materials for composting.
- US Composting Council (USCC) should help disseminate the following information :
 - “highest and best use” for cartons is recycling, not composting
 - only certified ASTM 6400 or EN 13432 tested products, or Biodegradable Products Institute (BPI) approved products should be allowed in food waste collection programs.
- American Plastics Council, Sustainable Packaging Coalition and major packagers should work to develop clear symbols for consumers to determine whether a container is compostable, recyclable or must be landfilled.
- Packaging industry should be held responsible to verify that packaging labeled compostable is truly compostable according to the above standards .

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www.ecocycle.org/microplasticsincompost