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

Recent research shows:

• Some 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

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Increasing the amount of organic material diverted from the waste stream
US Compost Collection Programs

According to the March 2018 issue of BioCycle:

- 326 programs in the US have residential food waste collections (up from 95 in 2009)
- 5.1 million households served
- In 2009, approximately half of the programs accepted plastic-coated paper products, now less than 10%
- Contamination is still a significant issue!
Some 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
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 BPI (Biodegradable Plastics Institute) approved ASTM D6400 test facility
- 180 day test for determining aerobic biodegradation of plastic materials under controlled composting conditions (2010)
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.

Minute Maid/LDPE & Nylon

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

Nesquik/LDPE

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

Stouffer's Tray/PET

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

Stouferr's Box/LDPE

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

Tropicana/LDPE Blend

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

- Plastic coatings did not biodegrade.
- Coatings retarded the biodegradation of the paper layer.
- When coated on both sides, little degradation occurred.
- Microplastic 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 paper stock almost entirely inhibited the biodegradation process.

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

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

Woods End Laboratory data
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% are coated with PE, and would be expected to shed microplastics in the same way as other PE-coated samples.
Further Findings

- Plastic fragments smaller than ½ inch would pass through screening into the final compost.
- Compost facilities do not generally sieve finer than this.
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
In addition to this study done in 2010, a more recent study done in Germany in 2018 tested finished compost made from bio-waste that originated from both households and commercial sources. The study found microplastics present in all samples, including polyethylene and polystyrene, which are frequently used in food packaging. Both of these plastics are known to be highly persistent in the environment. 

(Weithmann et al. 2018)
“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.

Including:
Suffocation
Entanglement
Starvation

Seal entangled in plastic  Photographer unknown

Snapping turtle deformed by plastic

Albatross chick ingesting plastic

[Jeanne Gallagher]  photographer, Cynthia Vanderlip

[Jeanne Gallagher]  unknown--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)
Plastics Fragments Ingested by Marine Organisms

“...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):

Microplastics 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)

“In 2015, researchers sampled fish and shellfish being sold for human consumption in Indonesian and California markets. They found plastic and textile fibers in a quarter of the animals.” (Krieger, 2016)
"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
Latest Research Findings

- In one study in China, microplastics were found in the gut of 94% of dead terrestrial birds with diverse foraging behavior. Microplastics have also been found in the gut of freshwater continental birds with agricultural areas being the probable source.

- In another study, increasing concentrations of microplastics were found in soil, earthworm casts and chicken feces, representing possible transfer up trophic levels.

- Microplastic ingestion has also been shown to reduce the growth of earthworms, and might be a vector for transfer of toxic zinc into their tissues.
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.
Contact information:

- Dan Matsch
  Cyndra Dietz
  Eco-Cycle, Inc.
  Boulder, CO
  www.ecocycle.org
  303.444.6634
dan@ecocycle.org

- Will Brinton
  Woods End Laboratories, Inc.
  Mt. Vernon, ME
  www.woodsend.org
  207.293.2457
  compost@woodsend.org

www.ecocycle.org/microplasticsincompost