Contaminants of Emerging Concern (CECs): Implications for Compost Quality, Use, & Marketing

Pathogens, Antibiotics & Antibiotic Resistance

Deborah Neher, University of Vermont

Implications for Compost, PFAS in particular

Ned Beecher, NEBRA

Chemical and Physical Contamination Issues

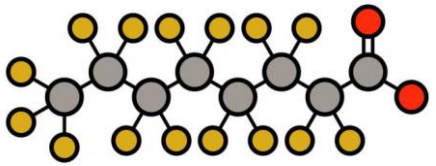
Andrew Carpenter, Northern Tilth

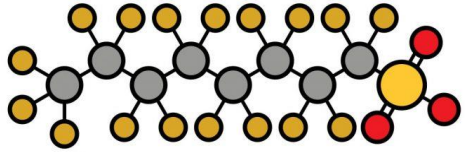
Microplastics

Deborah Neher, University of Vermont

Questions and Discussion

Perfluoroctanoic acid (PFOA)



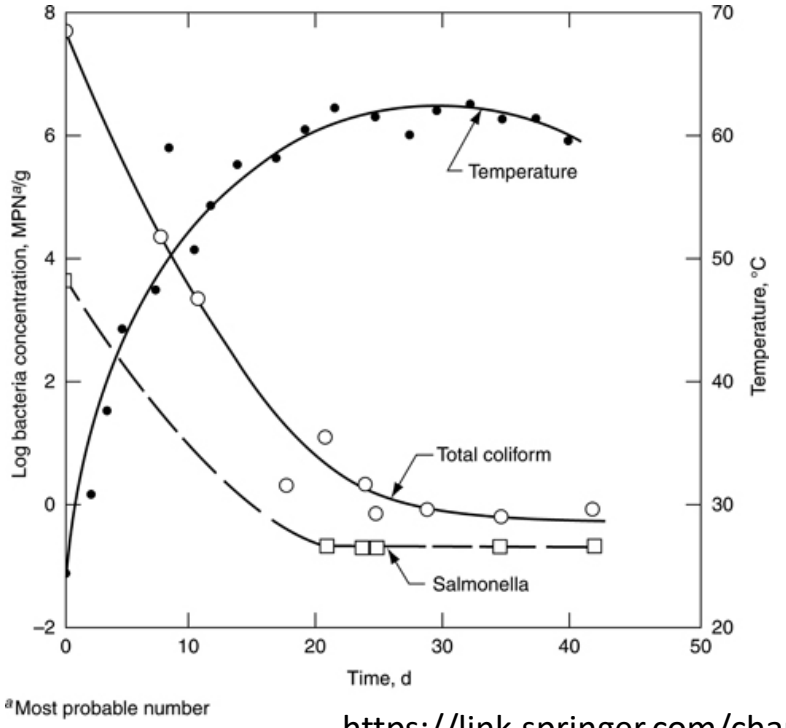


Perfluorooctanesulfonic acid (PFOS)

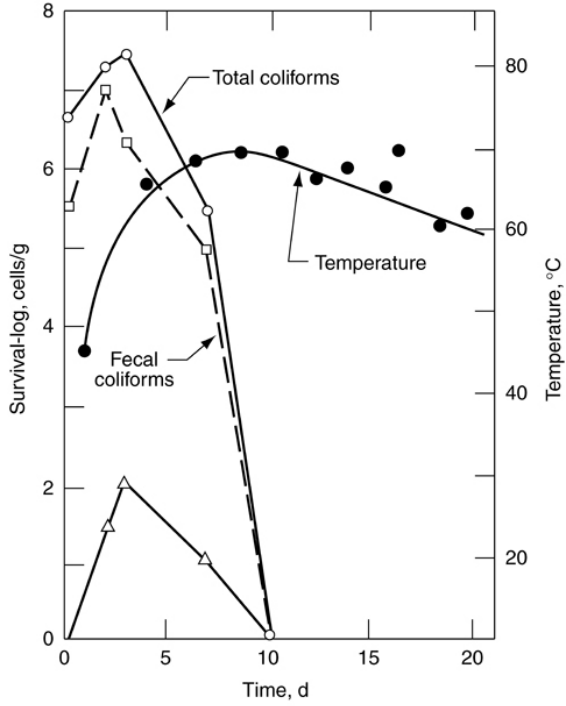
Destruction of pathogenic organisms as a function of time and temperature

- U.S. EPA & USDA – ARS (1970s)
- most killed at temps > 55 -70°C (131-170 °F)
- Temperature achievement
  - Initial C:N 25:1 to 40:1
  - ~ 60% moisture
  - Aeration
    - 5 turns in 15 days (windrow)
    - 3 days (ASP)

windrow method

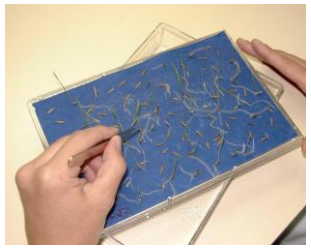


aerated static pile method



https://link.springer.com/chapter/10.1007/978-1-60327-156-1_16

Organic Program guidelines “work”



Crab grass seed
(*Digitaria sanguinalis)*

Early blight pathogen
Alternaria brassicinae

“cold” compost just takes longer!

Neher et al (2015) ***Agroecology and Sustainable Food Systems*** 39:3-18. DOI:10.1080/21683565.2014.884516

NORTHEAST SARE Sustainable Agriculture Research & Education

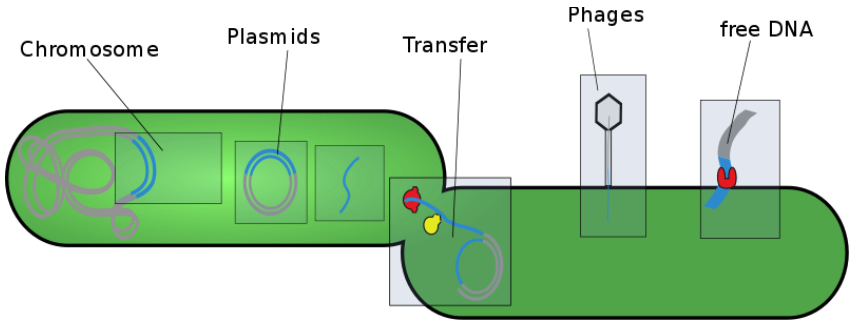
Pathogens managed with proper composting of manure

Bacteria	protozoa	Oomycota	Fungi	Nematodes
Coliforms, *e.g., E. coli* 0157:H7[C]	*Giardia*	*Pythium* spp.	*Fusarium*	*Pratylenchus* (lesion)
Salmonella spp[P]	*Cryptosporidium* [C,S,Sw]	*Phytophthora* spp.	*Verticillium dahliae*	*Meloidogyne* (root knot)
Listeria[C,S]			*Rhizoctonia solani*	
Clostridium				
Campylobacter[P]				
Streptococcus aureus				

Viruses are obligate parasites and won't survive without living host

Antibiotics, resistant bacteria, & antibiotic resistance genes

- Wastewater treatment plant effluent, sludge and manure are the main sources of contamination by antibiotics
- Antibiotic resistance is a major concern for public and environmental health
- Compost is more effective at destroying antibiotics in sewage than wastewater treatment plants



Mobile genetic elements in the cell (left) and the ways they can be acquired (right)

Comparison of Organic Waste Treatment Options

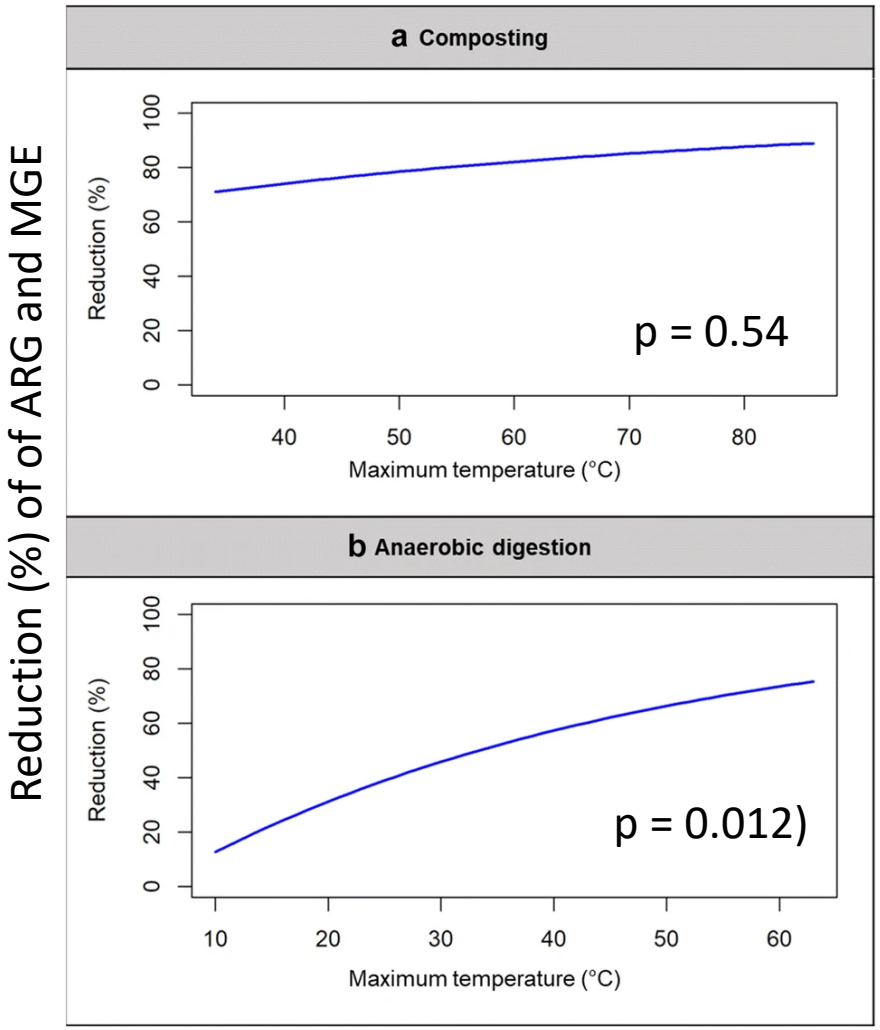
% reduction of the relative abundance of antibiotic resistance genes and mobile genetic elements after each organic waste treatment

Organic waste treatment	*n* studies (proportion in %)	Average % reduction [95% CI]	p-value	Global effect size
Aerobic digestion	3 (4.2 %)	58 % [-403 %; 96 %]	0.497	
Aerobic lagoon storage	1 (1.4 %)	61 % [-666 %; 98 %]	0.537	
Anaerobic digestion	28 (39.4 %)	51 % [-2 %; 77 %]	0.068	
Anaerobic lagoon storage	2 (2.8 %)	48 % [-648 %; 96 %]	0.637	
Composting	27 (38 %)	84 % [65 %; 93 %]	<0.001*	
Drying/dewatering	5 (7 %)	98 % [80 %; 100 %]	0.001*	
Pasteurization	1 (1.4 %)	-25 % [-749 %; 82 %]	0.819	
Pile storage	4 (5.6 %)	52 % [-135 %; 90 %]	0.369	

Positive % means a reduction while negative % means an increase

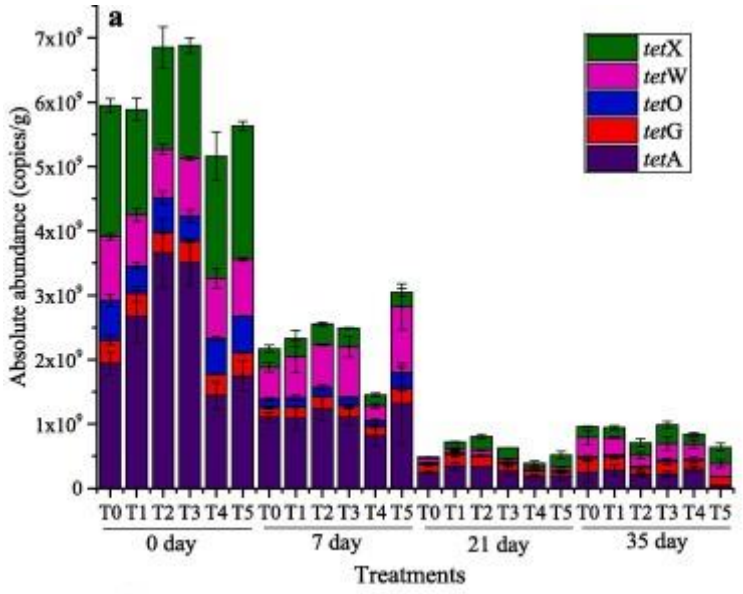
Goulas et al. (2020) Environmental Evidence 9, 4 (meta-data analysis, review)

Effect of maximum temperature

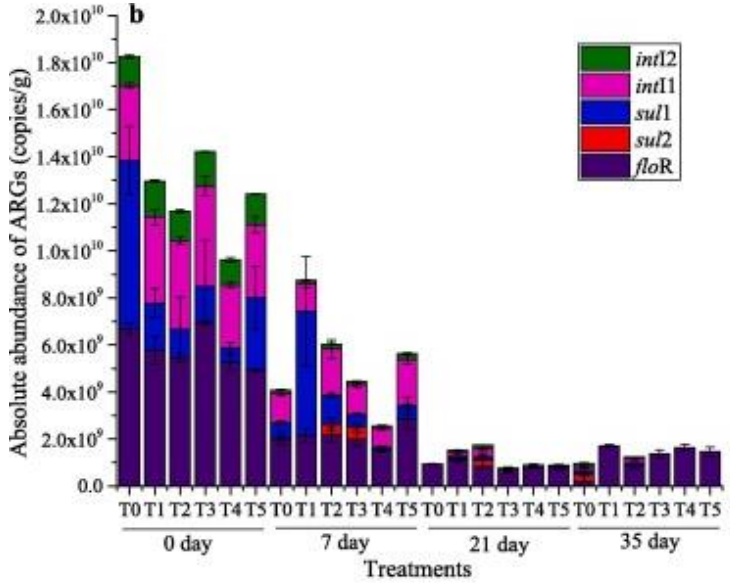


ARG: antibiotic resistance genes
MGE: mobile genetic elements

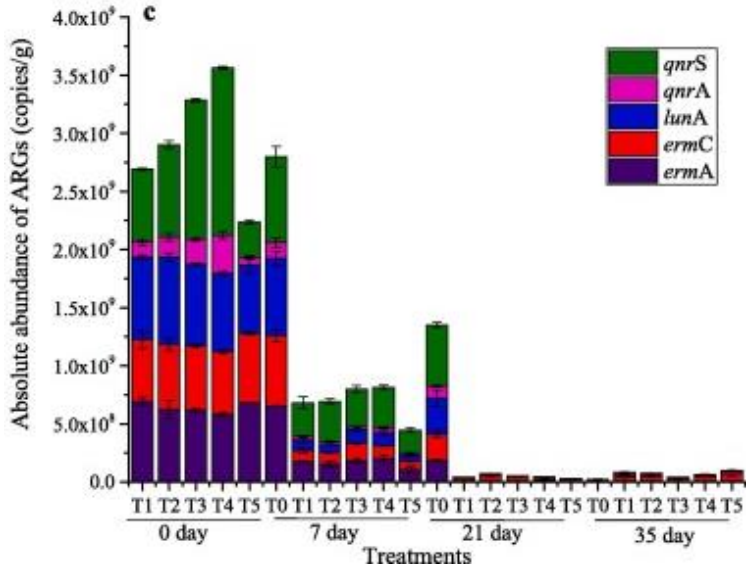
Commonly-used antibiotics in mixtures slow composting process initially, but regardless ARGs and integrons reduce through time of composting



Tetracycline resistance genes



integrons (intI1, intI2)
sulfonamide (sul1, sul2)
multiple resistance gene (floR)



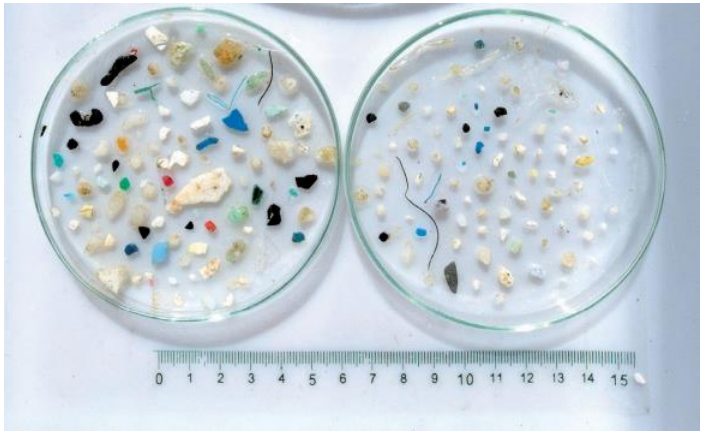
quinolone resistance genes (qnrA, qnrS)
macrolide (ermA, ermC, lunA)

Treatments spiked with 50 mg/kg of lincomycin, chlorotetracycline, sulfamethoxazole, and ciprofloxacin and a mixture of 4 antibiotics and represented by T1, T2, T3, T4, and T5, respectively. T0 is no antibiotic control

Song et al. (2020) Bioresource Technology 315 (2020) 123820

Microplastics

("size" not "type")



Primary

- fragments or particles ≤ 5.0 mm
  - microfibers from synthetic clothing, microbeads, and plastic pellets (nurdles)
  - 'scrubbers' for exfoliating hand cleaners and facial scrubs
  - air blasting technology: machinery, engines, boat

Secondary

- created from fragmentation of larger plastic products
  - water and soda bottles, fishing nets, plastic bags
  - Jagged edges

Agriculture plastics

Silage wrap/bunk covers

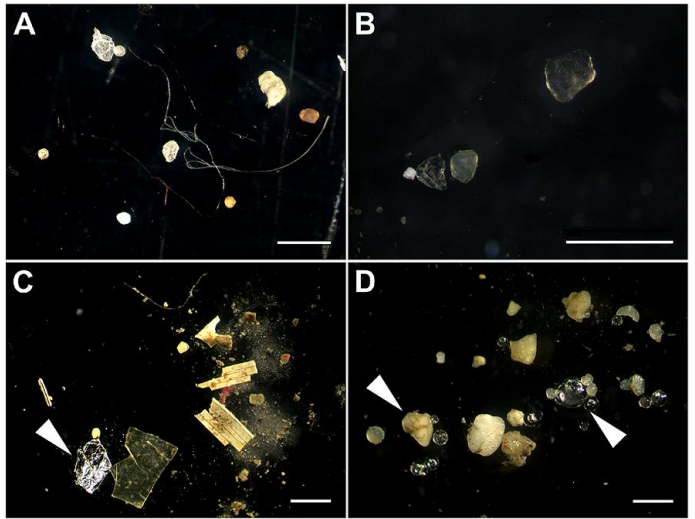
Nursery pots, trays, flats

Maple tubing (PE only)

Greenhouse film

Bale wrap

Drip tape/irrigation tubing



Concern of depackagers

- Early models used hammermills that splinter packaging, allowing small particles to pass through screen
- Newer models use least applied force necessary to avoid splintering the packaging

Twin screws in the bottom of the feed hopper (left) tear open cardboard boxes and other containers while conveying the contents to the separator.

Photos by Bob Spencer

Depackaging Steps

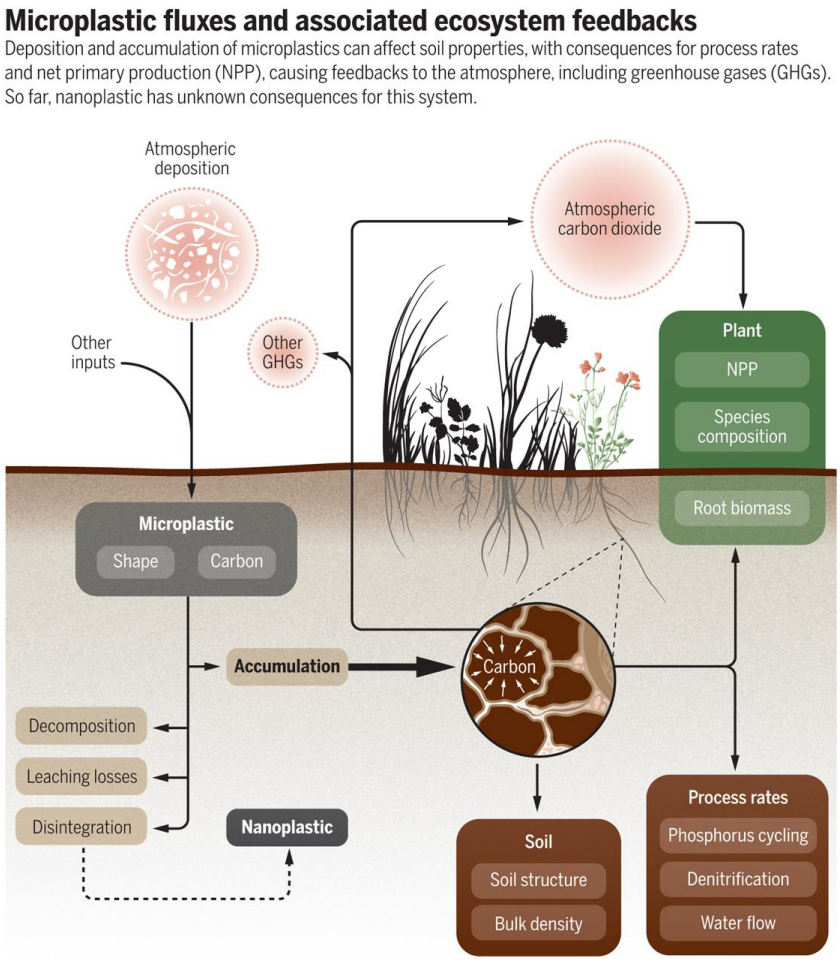
The major steps in the E.L. Harvey food waste processing system include:

1. Loading the feed hopper
2. Twin flight screws start to break up containers and feed material into separator
3. Operators decide if liquid should be added depending on desired product
4. Partially ruptured packaging drops into separator, which is a horizontal shaft with flat paddles that liberates the organics, which in turn fall through the screen. Packaging is retained, exiting the end of the machine
5. Food product is conveyed into a tank to be pumped into a truck, or into a roll-off container if it is animal feed, or composting feedstock.
6. Separated packaging is conveyed into a hopper where it is then taken for disposal.

Concern: Bioaccumulation in food chain

- Microscopic plants and animals
  - ‘empty’ calories
- Earthworms
  - External
    - adhere to epidermis
    - dispersal in burrows
  - Evidence of consumption
    - Egestate
    - Casting activity
      - Modified behavior
- Humans

Polyethylene microplastic particles incorporated into surface middens (bottom) and adhering to the skin of earthworms (top)



Rillig & Lehmann, Science, June 2020

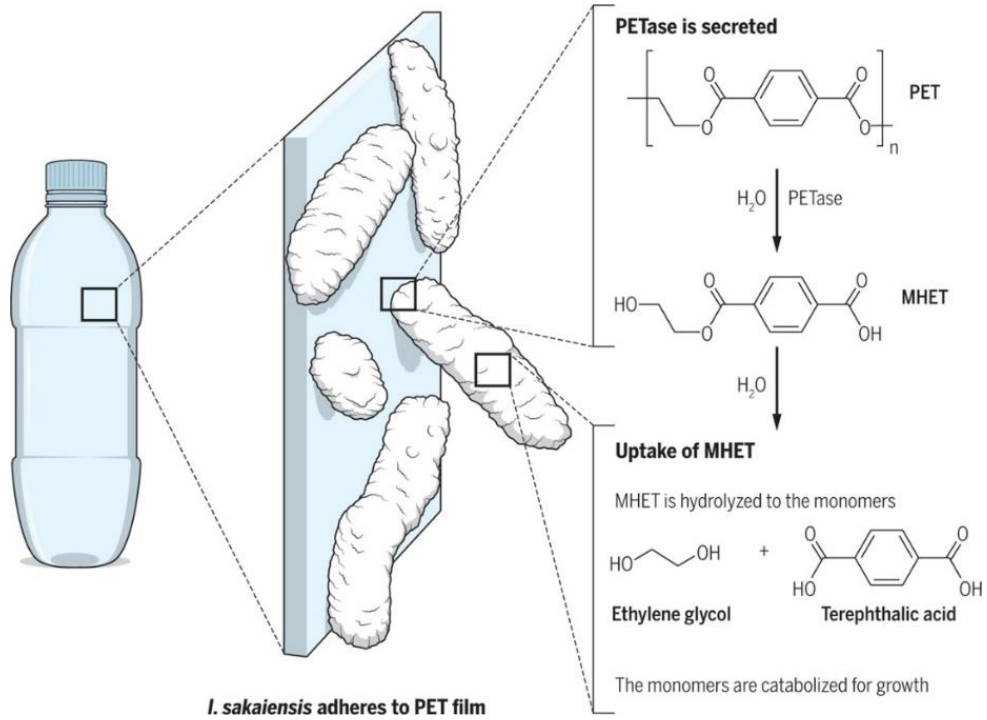
Search for plastic-eaters

Beetle larvae (mealworms) dine on polystyrene, then excrete the brown material, which contains trace amounts of chemicals

- Depolymerization of ingested styrofoam by gut microbiota
  ≤ 36.7% of ingested styrofoam mineralized into CO_2

Stanford University scientists
San Francisco Chronicle, Peter Fimrite (12/20/19)

Ideonella sakainesis can break down PET (polyethylene terephthalate) commonly found in water bottles



Japanese scientists
Uwe T. Bornscheuer Science 2016;351:1154-1155

Contact information for speakers

Ned Beecher, Special Projects Manager
PO Box 422
Tamworth, NH 03886
603-323-7654
ned.beecher@nebiosolids.org
603-323-7654, x2

Deborah Neher, Ph.D.
Professor of Plant and Soil Science
University of Vermont
dneher@uvm.edu
www.uvm.edu/~dneher
www.uvm-roar.com/

Natasha Duarte
Director, Composting Association of Vermont
PO Box 643 Hinesburg, VT 05461
802-373-6499
natasha@compostingvermont.org

Andrew Carpenter
Northern Tilth
P.O. Box 361 Belfast, Maine 04915
phone 207-338-5500 fax 207-338-8833
soils@northerntilth.com