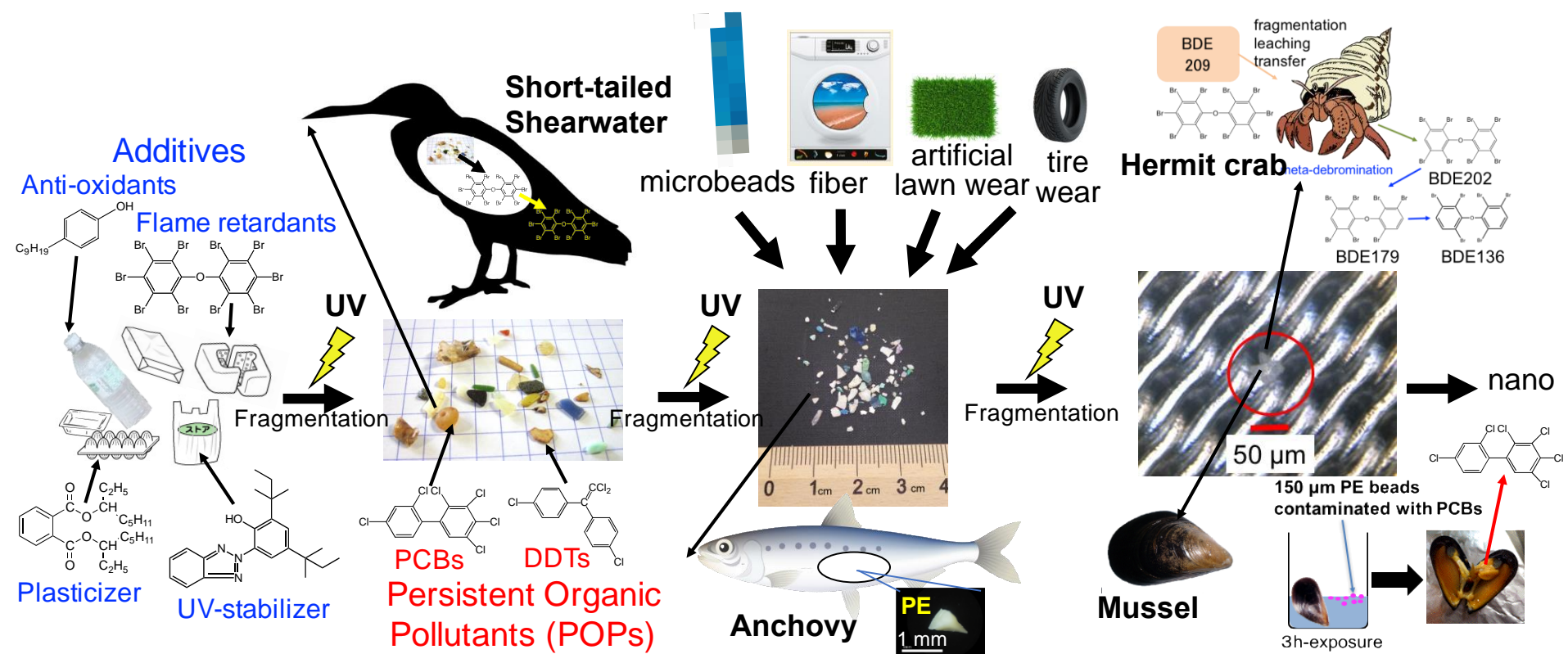


Microplastic and landfill leachate as sources of plastic additives



Hideshige TAKADA

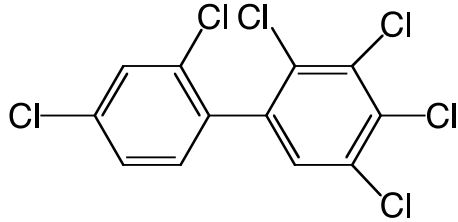
Laboratory of Organic Geochemistry (LOG)
Tokyo University of Agriculture and Technology

Topics

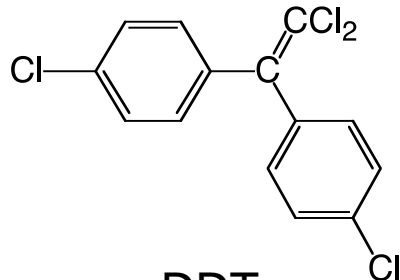
- Hazardous chemicals in marine plastics
 - Chemicals adsorbed from seawater
 - Additive chemicals
- Transfer and accumulation of the chemicals from ingested plastics to internal tissue of biota
 - Direct evidence by semi-field feeding experiment
 - Facilitated leaching by oily components in digestive fluid
- Bisphenol A in landfill leachate
- Debromination of PBDEs in landfill leachate

Plastics carry two types of chemicals in marine environment

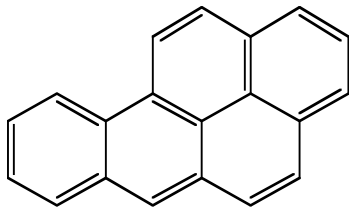
Sorption from seawater



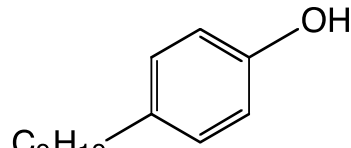
Polychlorinated biphenyl (PCBs)



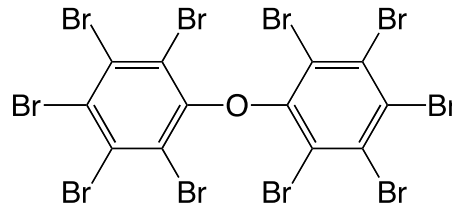
DDTs



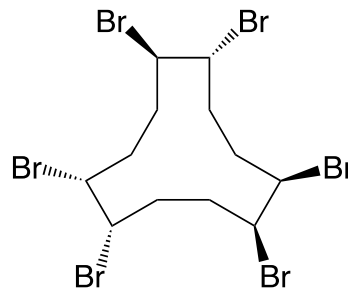
Polycyclic aromatic hydrocarbons (PAHs)



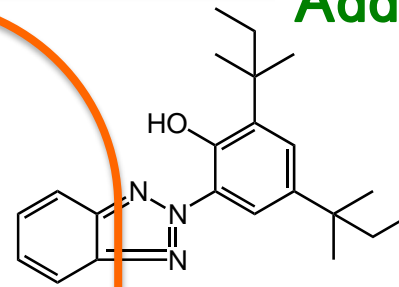
Nonylphenol



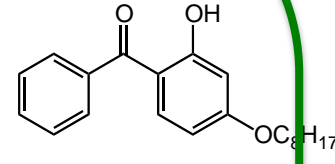
Polybrominated diphenyl ethers (PBDEs)



Hexabromocyclododecanes (HBCDs)

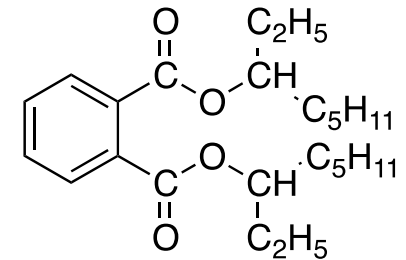


Benzotriazoles (e.g., UV-328)

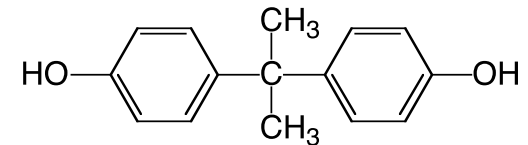


Benzophenones (e.g., BP-12)

Additives



Phthalates (DEHP)

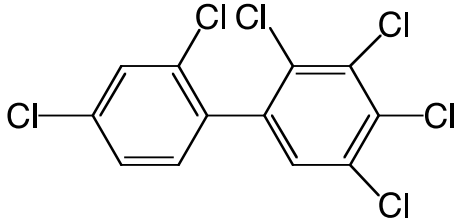


Bisphenol A

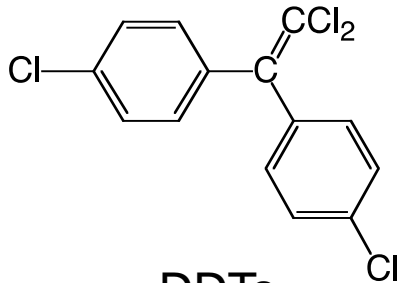
DBDPE

Plastics carry two types of chemicals in marine environment

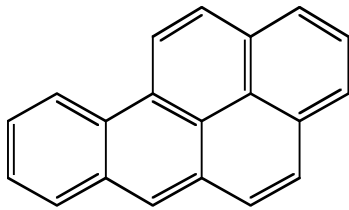
Additives



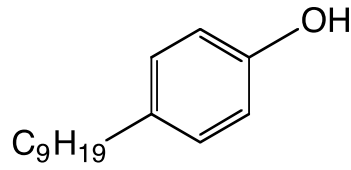
Polychlorinated biphenyls (PCBs)



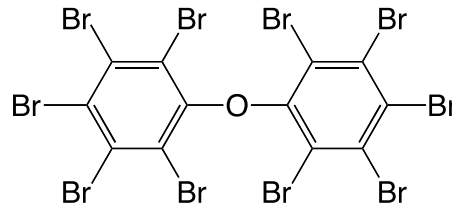
DDTs



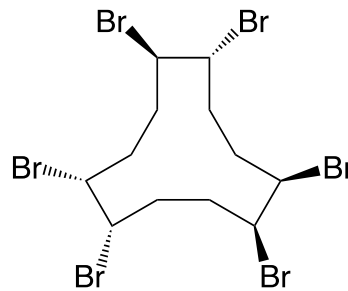
Polycyclic aromatic hydrocarbons (PAHs)



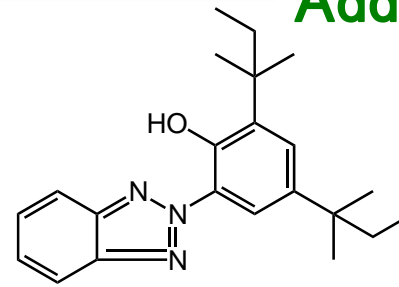
Nonylphenol



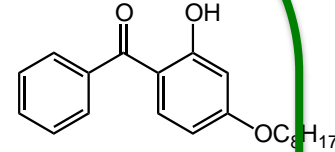
Polybrominated diphenyl ethers (PBDEs)



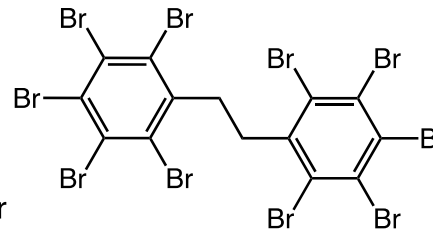
Hexabromocyclododecanes (HBCDs)



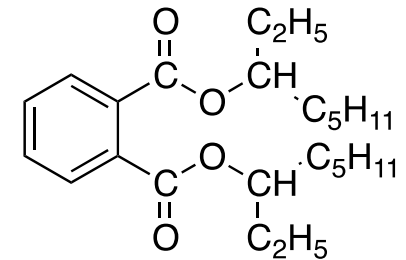
Benzotriazoles (e.g., UV-328)



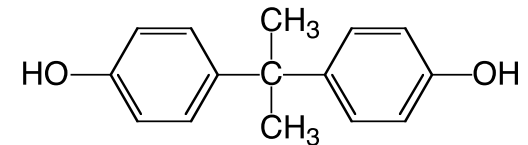
Benzophenones (e.g., BP-12)



DBDPE



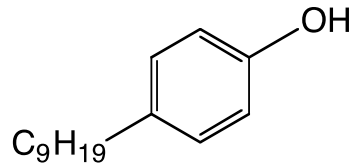
Phthalates (DEHP)



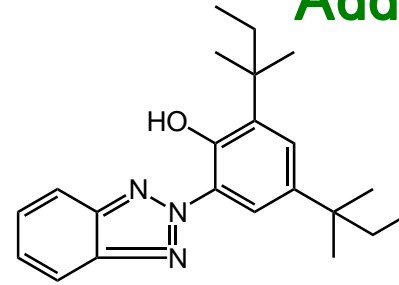
Bisphenol A

Hydrophobic additives and hydrophilic additives

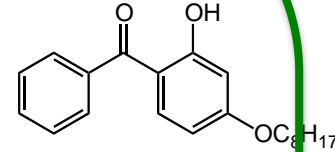
Additives



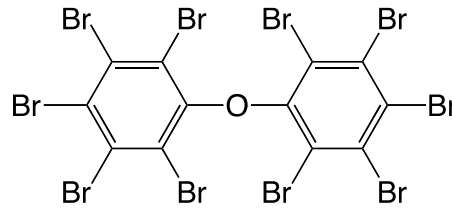
Nonylphenol



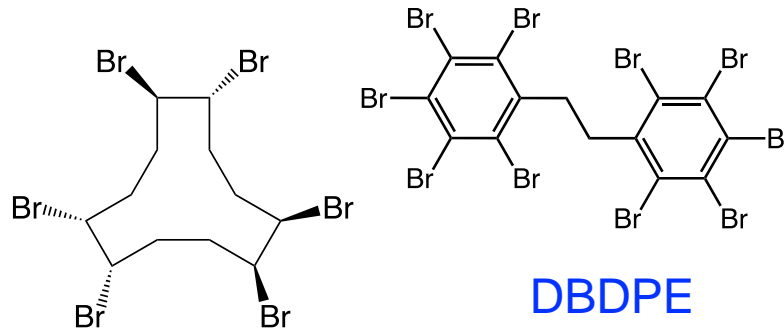
Benzotriazoles
(e.g., UV-328)



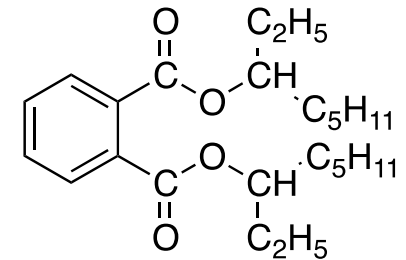
Benzophenones
(e.g., BP-12)



Polybrominated diphenyl ethers
(PBDEs)

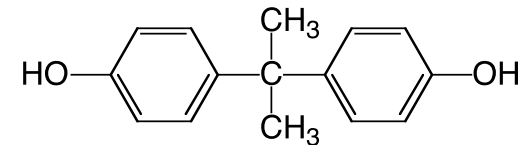


DBDPE



Phthalates
(DEHP)

Hexabromocyclododecanes
(HBCDs)



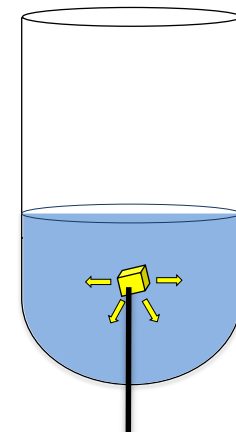
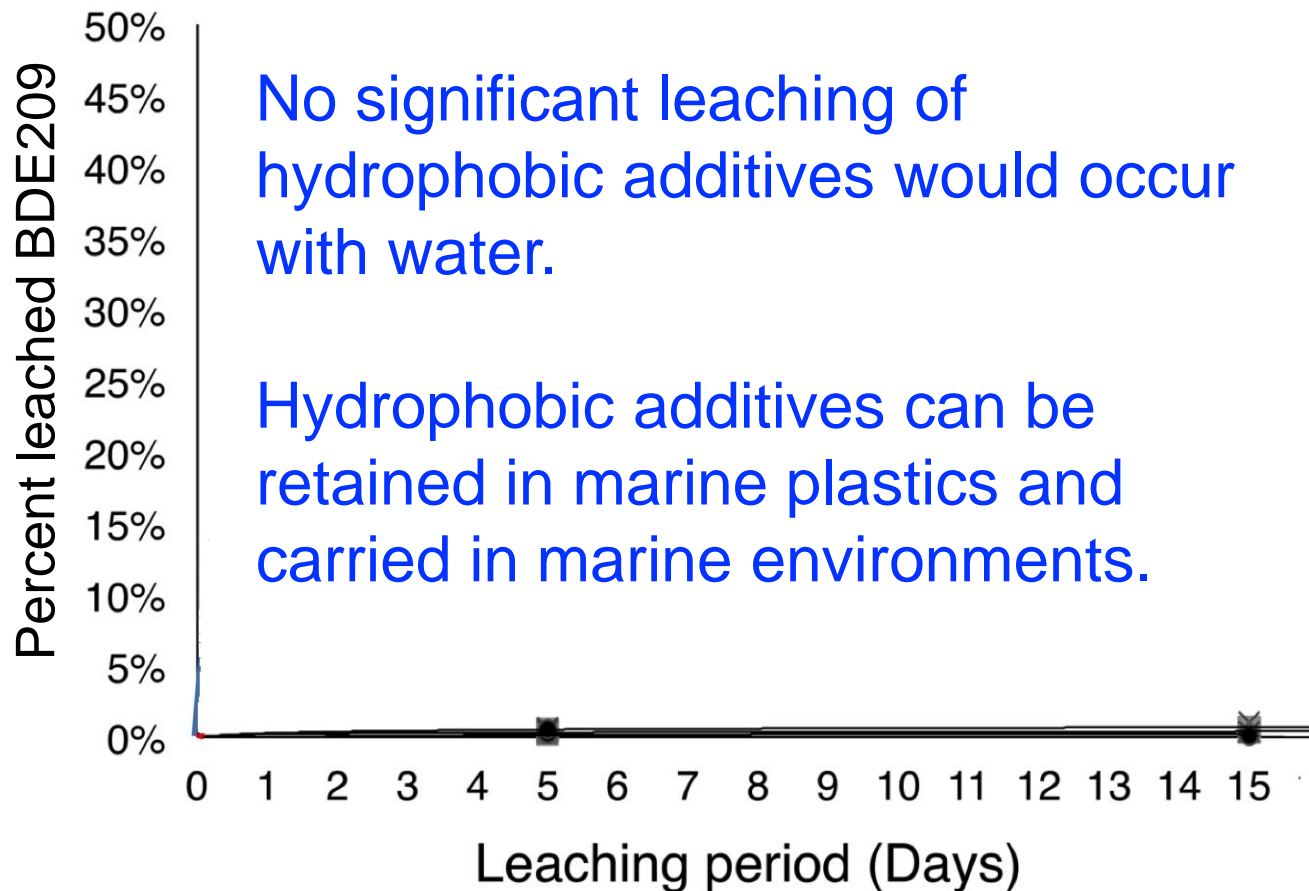
Bisphenol A

Hydrophobic additives are hard to be leached out to water

Facilitated Leaching of Additive-Derived PBDEs from Plastic by Seabirds' Stomach Oil and Accumulation in Tissues

Kosuke Tanaka,[†] Hideshige Takada,^{*,†} Rei Yamashita,[†] Kaoruko Mizukawa,[†] Masa-aki Fukuwaka,[‡] and Yutaka Watanuki[§]

DOI: 10.1021/acsc.5b01376
XXX-XXX

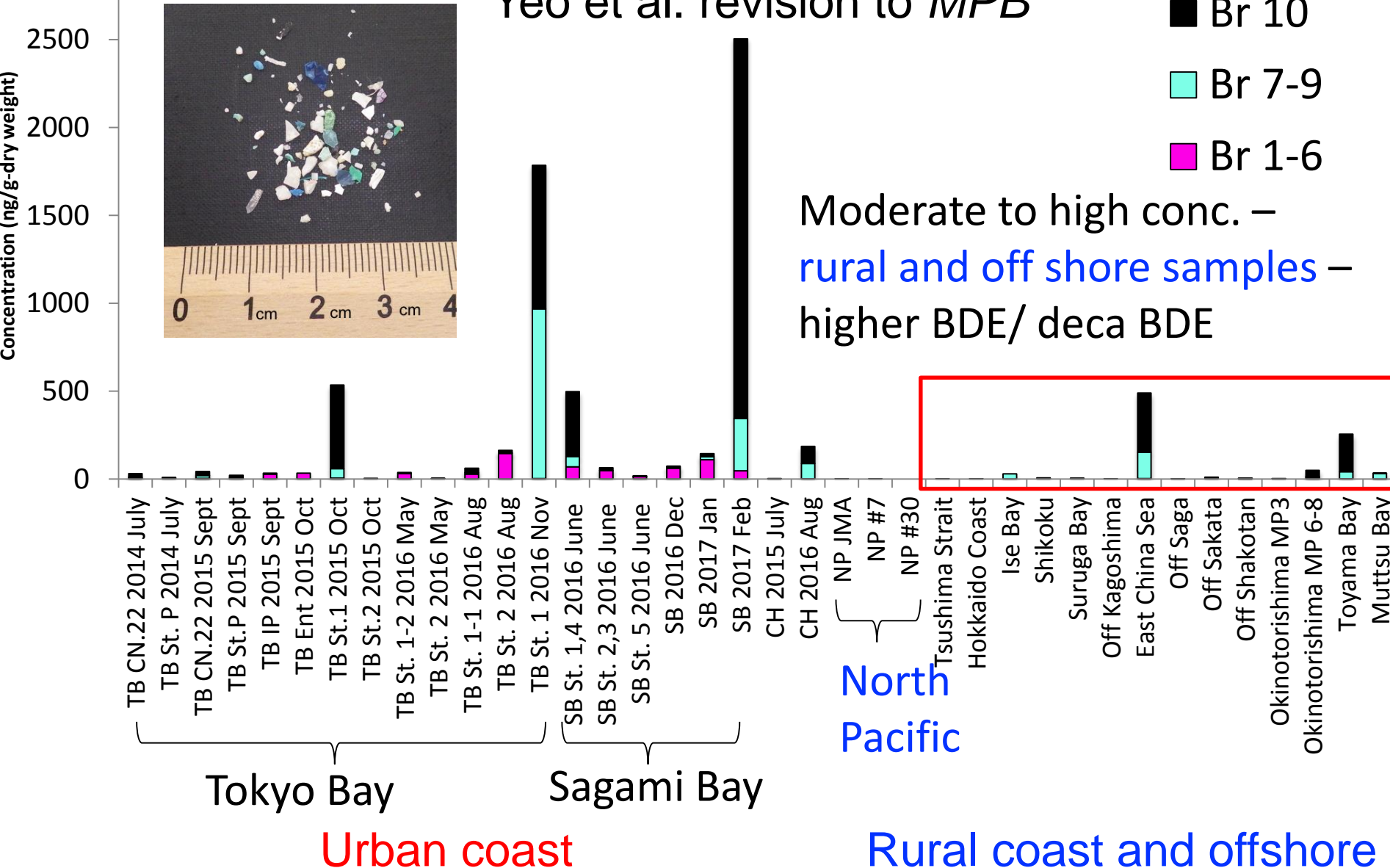


BDE209
in plastic

Pepsin solution
Sea water
Distilled water

BDE209 was sporadically detected in suspended microplastics suspended in seawater

Yeo et al. revision to *MPB*

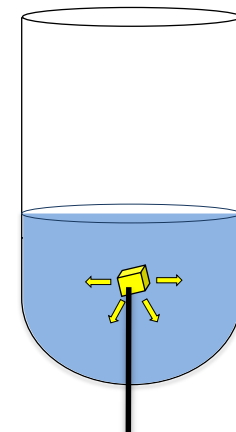
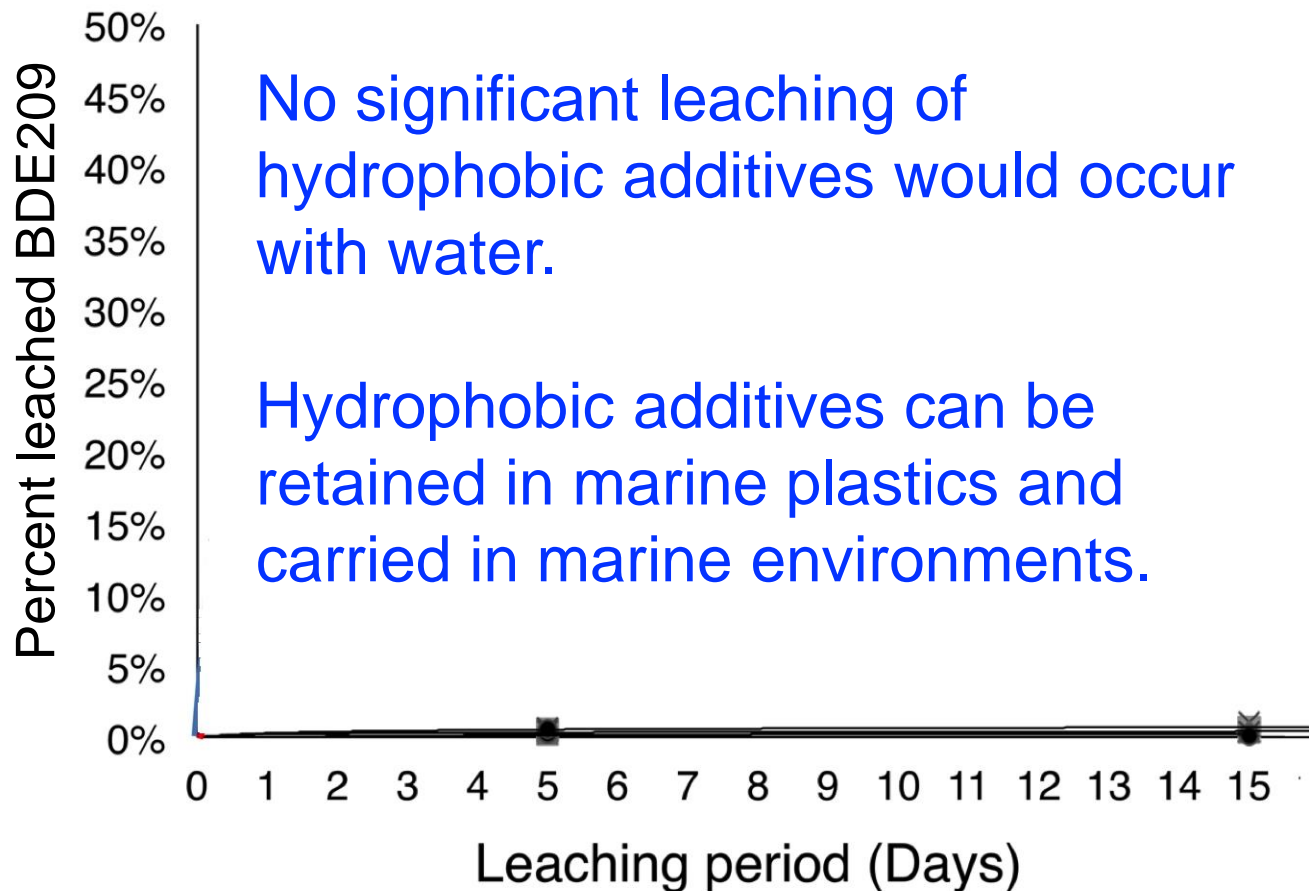


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XXX-XXX



BDE209
in plastic

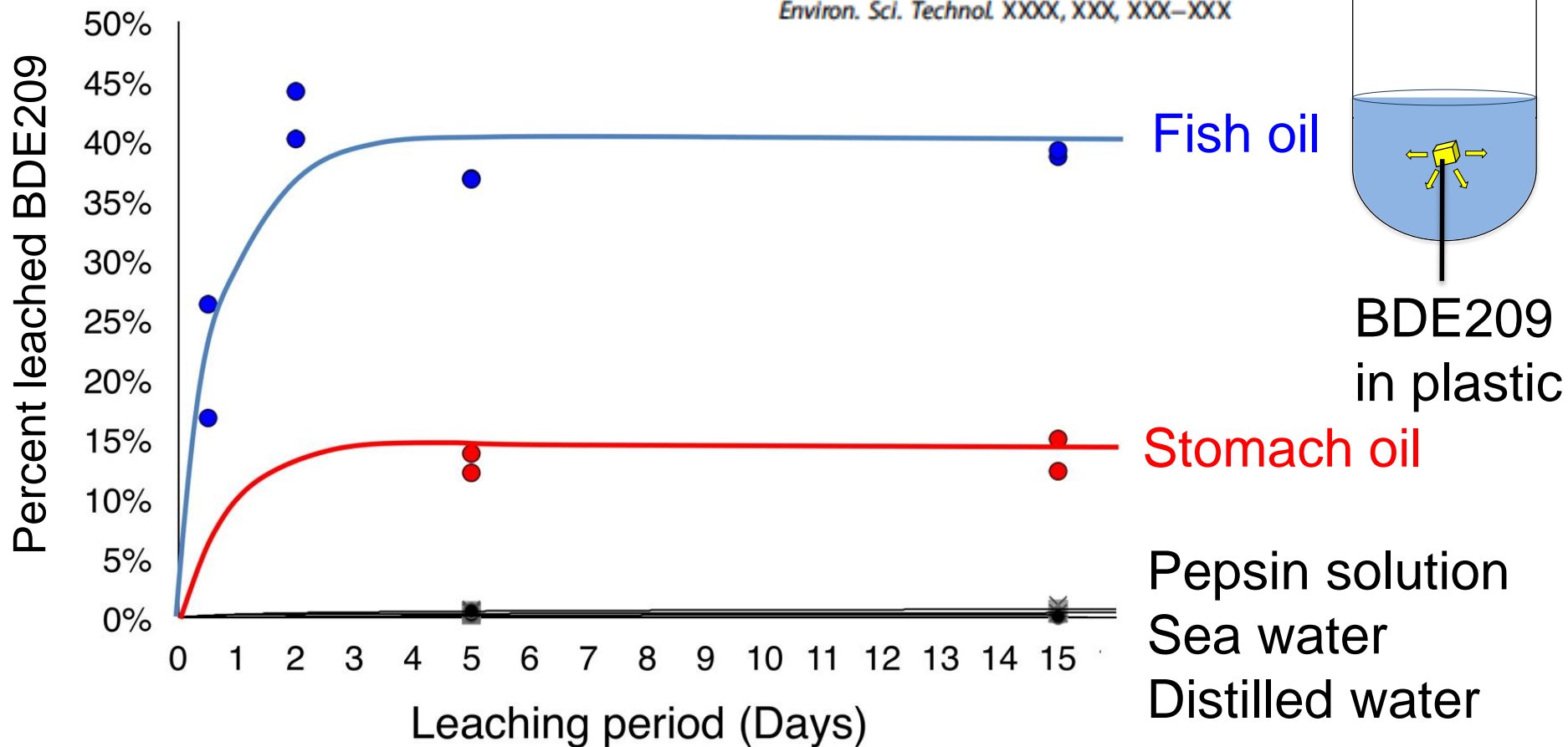
Pepsin solution
Sea water
Distilled water

Stomach oil and fish oil accelerated the leaching of BDE209

Facilitated Leaching of Additive-Derived PBDEs from Plastic by Seabirds' Stomach Oil and Accumulation in Tissues

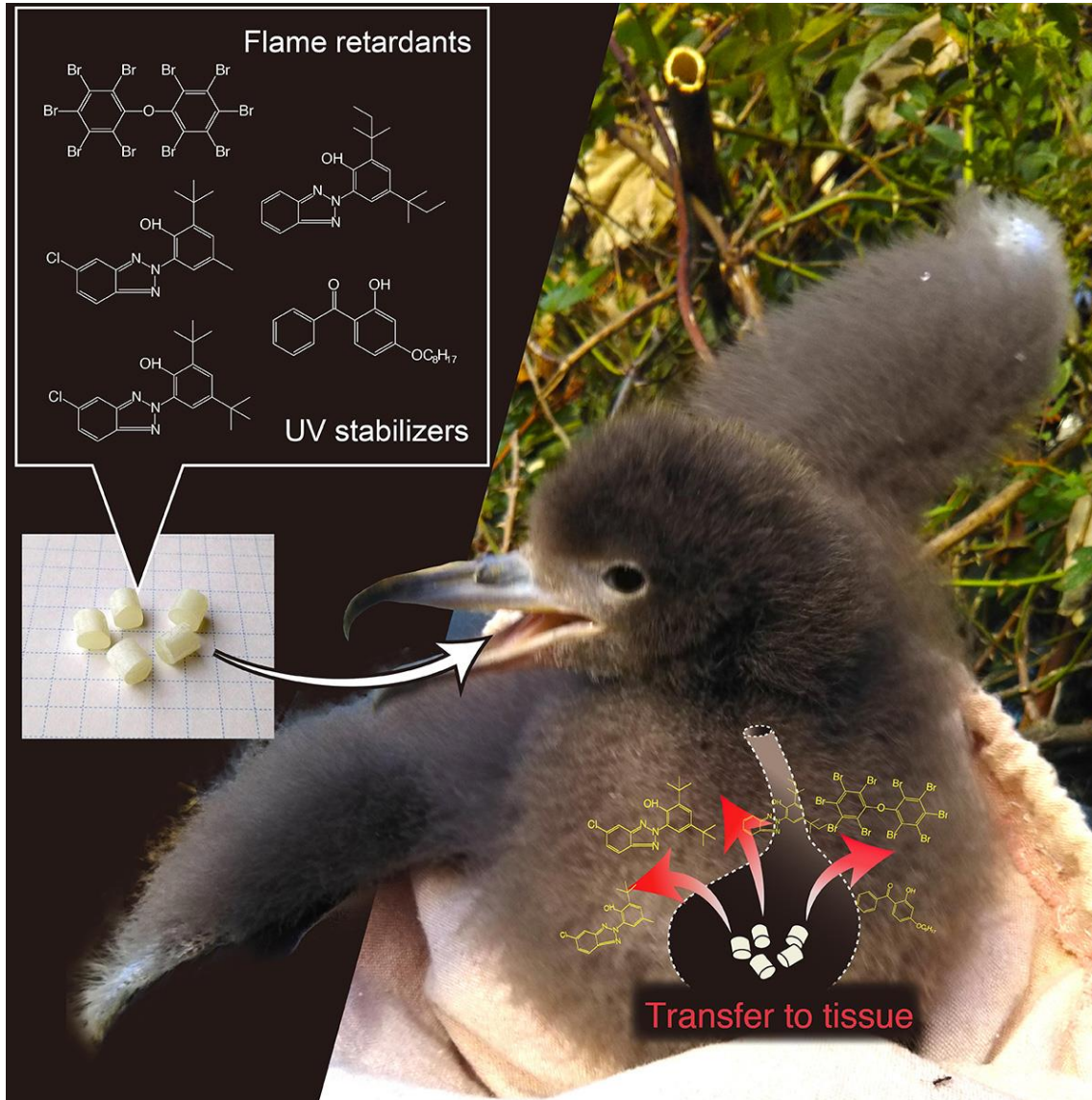
Kosuke Tanaka,[†] Hideshige Takada,^{*,†} Rei Yamashita,[†] Kaoruko Mizukawa,[†] Masa-aki Fukuwaka,[‡] and Yutaka Watanuki[§]

DOI: 10.1021/acs.est.5b01376
Environ. Sci. Technol. XXXX, XXX, XXX–XXX



This suggests that **fatty components** in digestive tract facilitates leaching of hydrophobic additives.

Direct in vivo evidence for accumulation of plastic derived chemicals in seabird tissue under environmentally relevant condition



Tanaka *et al.*
(2019)
Current Biology
(under review of revision)

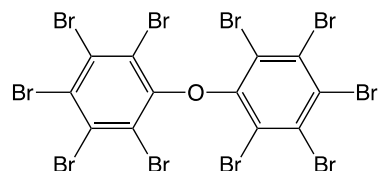
Plastics compounded with 5 additives

Polyethylene pellets with 5 additives

Additives:

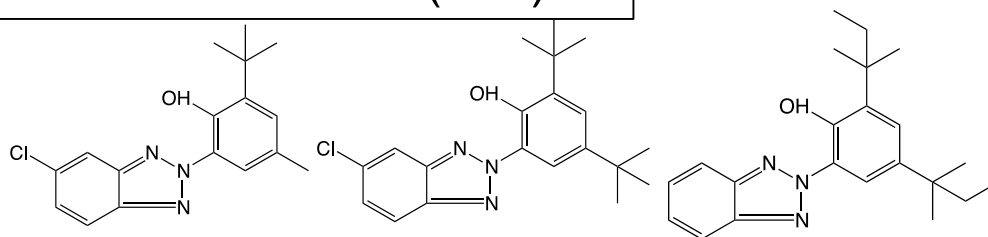
Brominated flame retardants

- BDE209



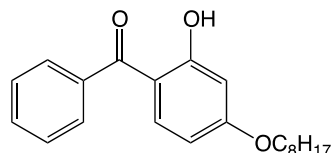
Benzotriazole UV-stabilizers (BTs)

- UV-326
- UV-327
- UV-328



Benzophenone UV-stabilizers (BPs)

- BP-12



Additives
+
PE powder

↓
mixed
melted,
molded
by using extruder



Concentration of each chemical was 0.4 % by weight in polymer.

Field Feeding Experiment of additive-compounded plastic to chicks of streaked shearwater

Exposure group

PE pellets compounded with 5 additives



(5 pieces /individual)

+



natural diet

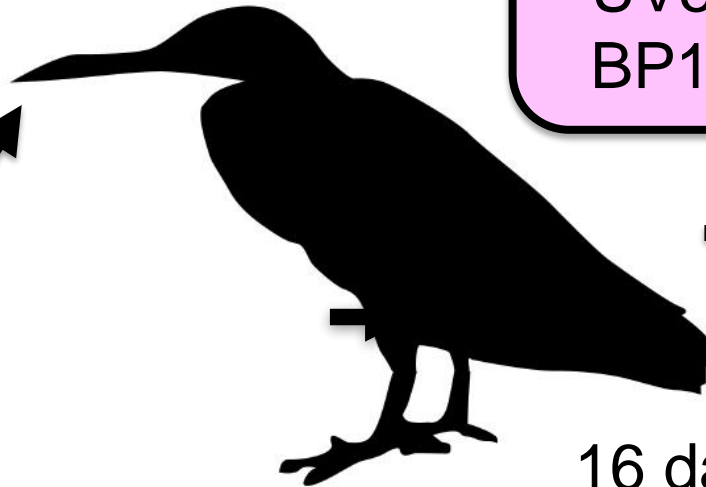
Control group

natural diet



natural diet

Chicks



16 days

- Liver
- Adipose
- Preen Gland oil

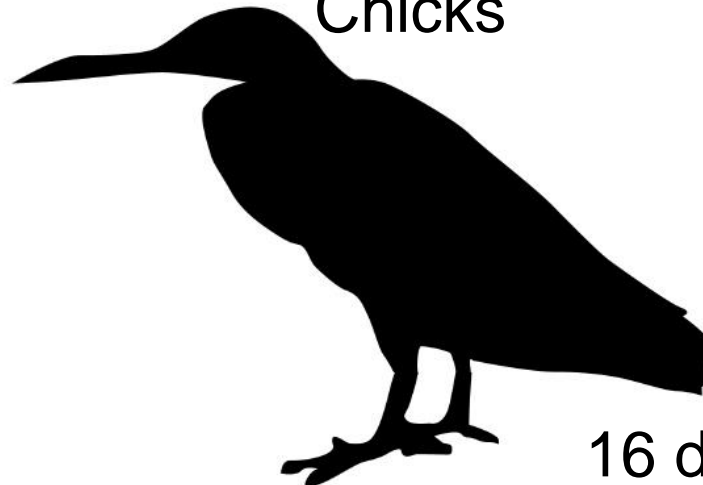
Additives

BDE209

UV326, UV327, UV328

BP12

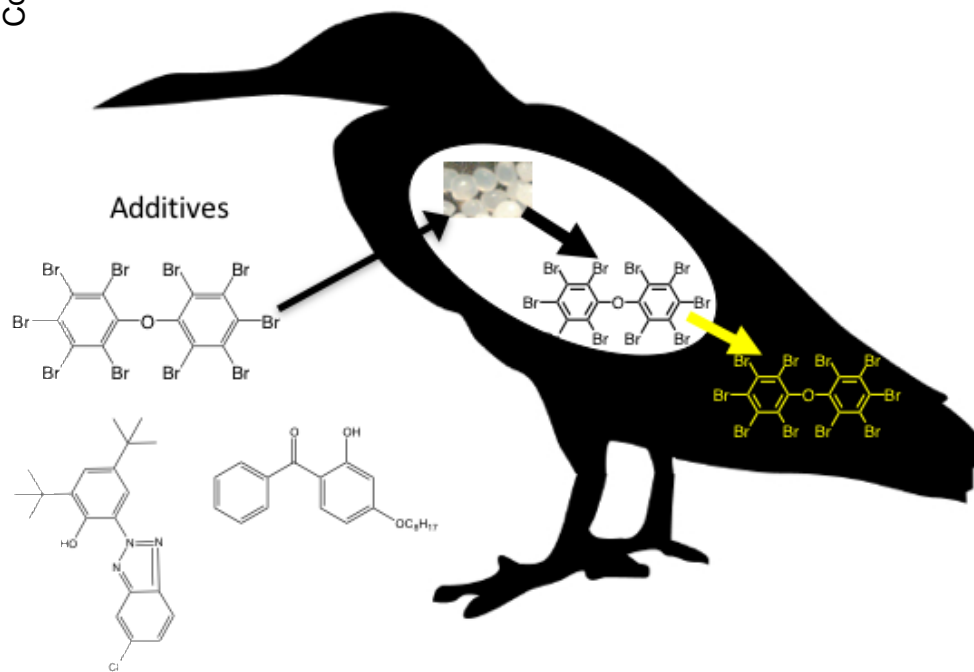
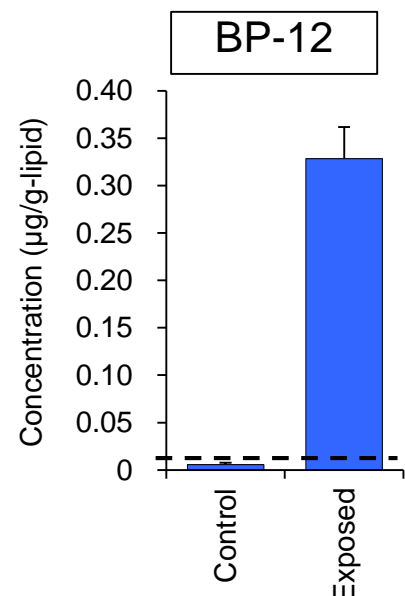
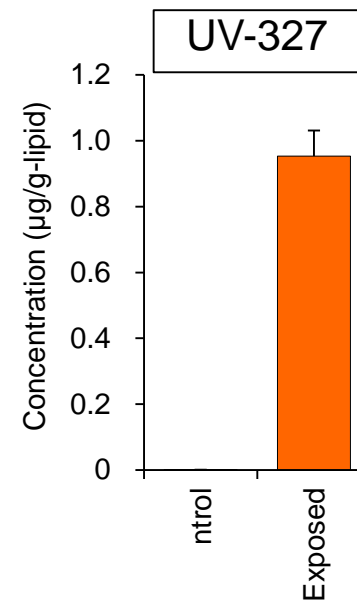
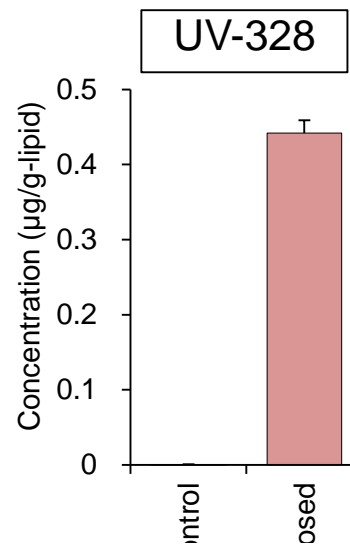
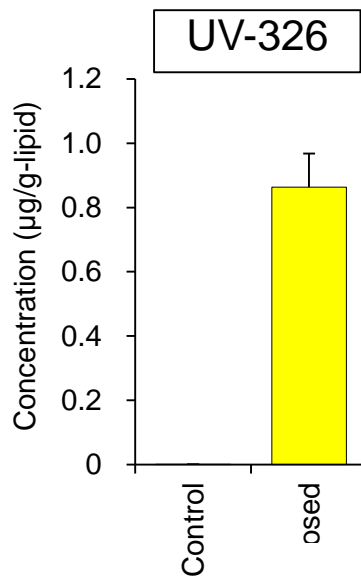
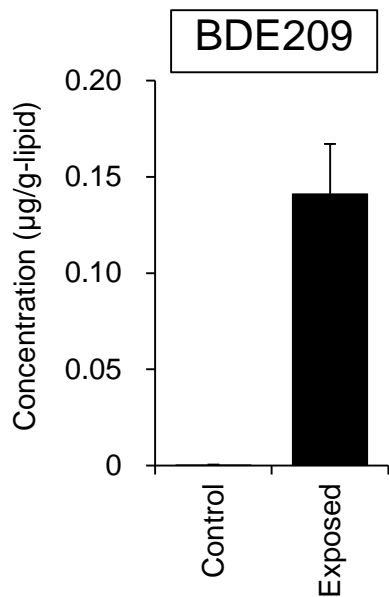
Chicks



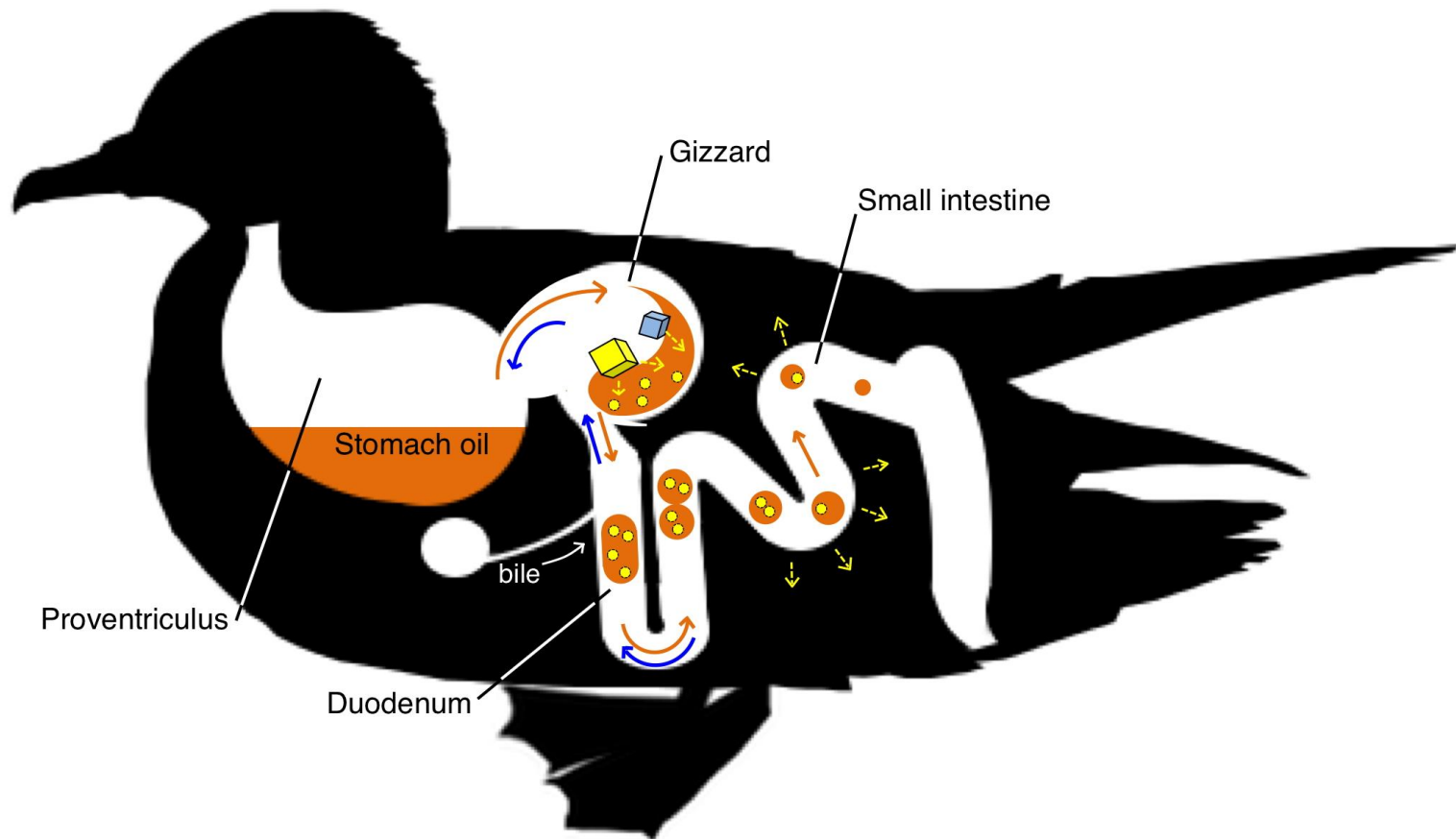
16 days

- Liver
- Adipose
- Preen Gland oil

Results_abdominal adipose (16 day)



Oily components in digestive fluid facilitate leaching of hydrophobic additives and their accumulation in adipose and liver

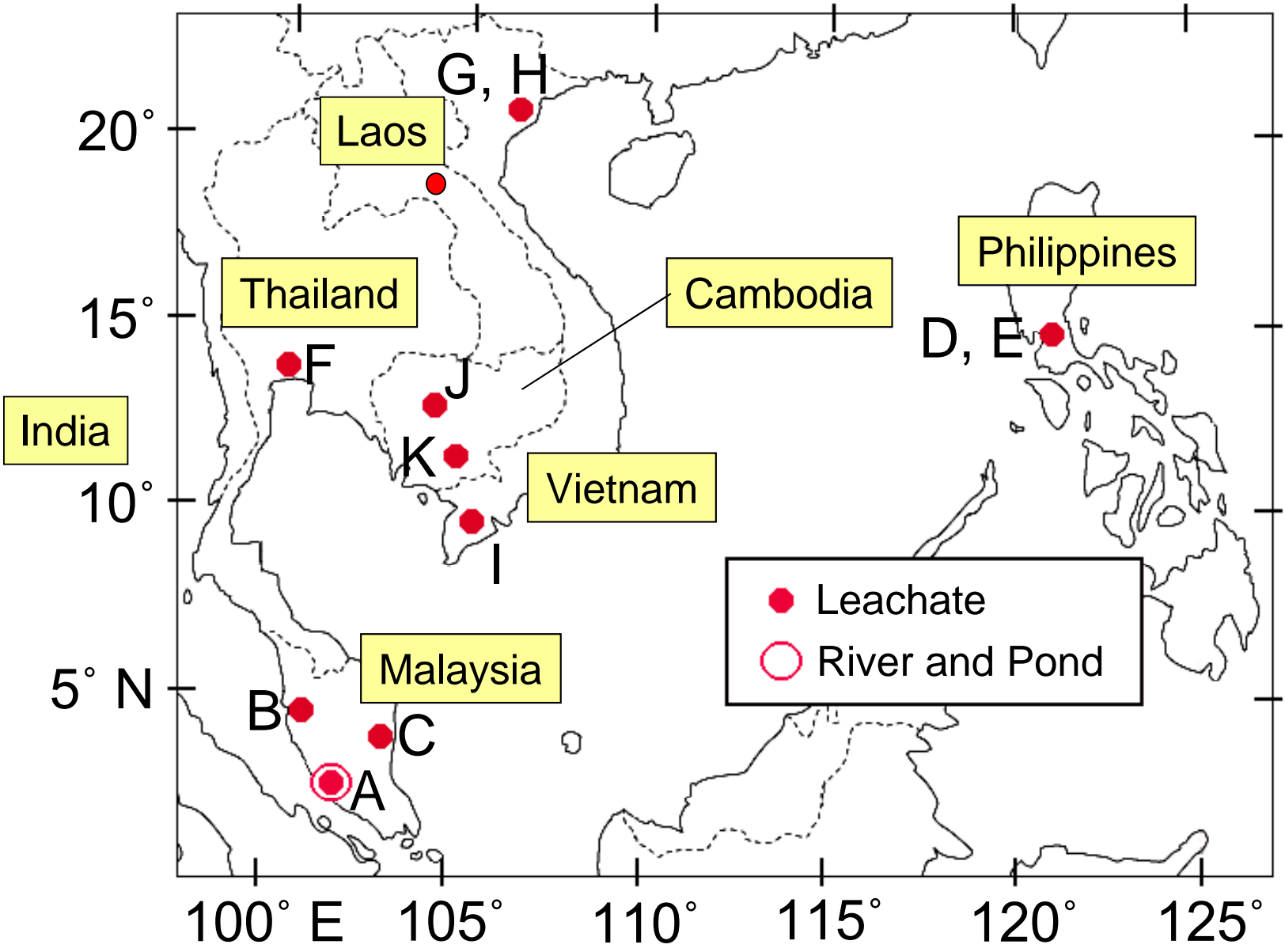


Tanaka, K., Yamashita, R., and Takada, H., *Transfer of hazardous chemicals from ingested plastics to higher-trophic level organisms*, in *Hazardous chemicals associated with plastics in environment*, H. Takada and H.K. Karapanagioti, Editor. 2018, Springer Berlin Heidelberg: p. 267–280.

Topics

- Hazardous chemicals in marine plastics
 - Chemicals adsorbed from seawater
 - Additive chemicals
- Transfer and accumulation of the chemicals from ingested plastics to internal tissue of biota
 - Direct evidence by semi-field feeding experiment
 - Facilitated leaching by oily components in digestive fluid
- Bisphenol A in **landfill leachate**
- Debromination of PBDEs in **landfill leachate**

Sampling locations of Leachate samples from Garbage dumping sites





Phnom Penh, Cambodia



Vientiane, Laos



Bangkok, Thailand



Hanoi, Vietnam



Jakarta, Indonesia



Kuala Lumpur, Malaysia



Smokey Mountain, Philippines



Payatas, Philippines



Can Tho, Vietnam

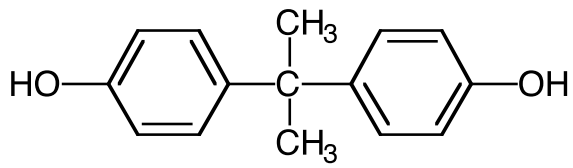


Kolkata, India

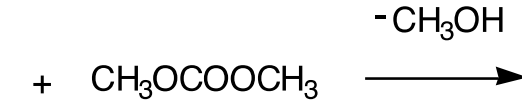


Smokey Mountain, Philippines

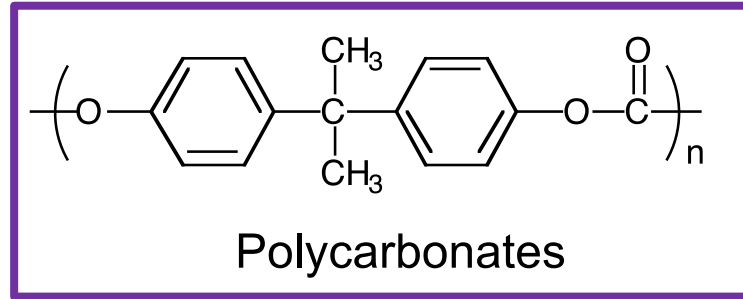
Endocrine disrupting chemicals



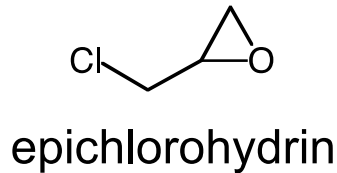
Bisphenol A (BPA)



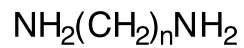
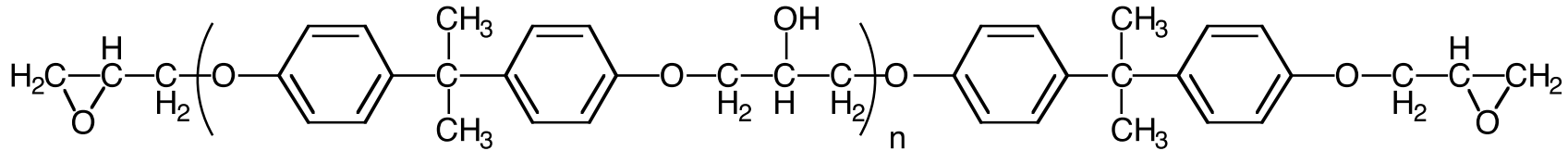
Dimethyl carbonate



Polycarbonates

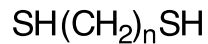


epichlorohydrin



Polyamine

or

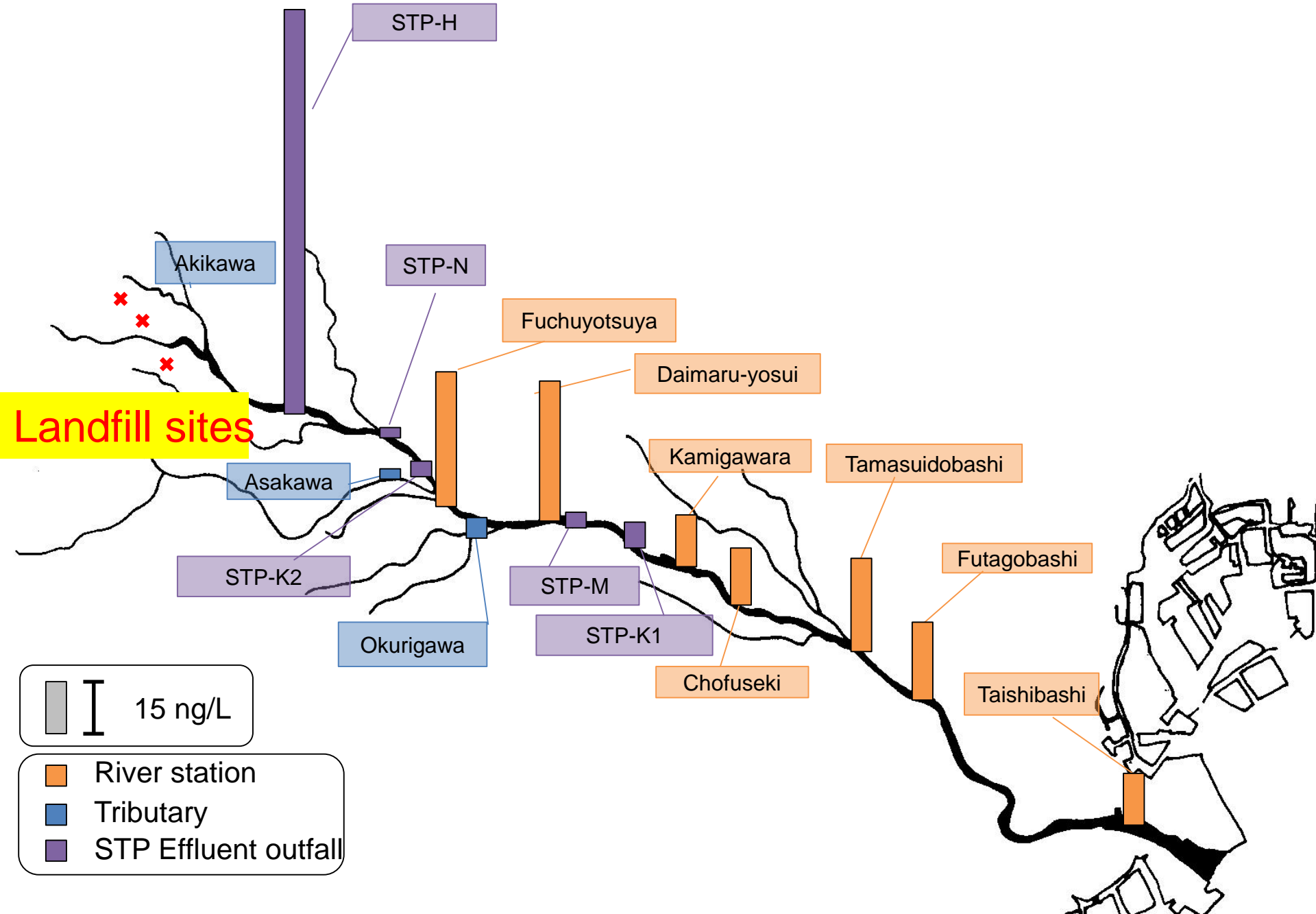


Polythiol

Epoxy Resin

Monomer (BPA) is generated and leached by heating of the polymers under acidic or basic condition. **BPA is also used as additives** for the other plastic polymers and can be leached out.

Landfill leachate is still major contributor of BPA in a river in Tokyo



Major Conclusions

Hydrophobic additives are retained in marine plastics and microplastics.

Leaching of hydrophobic additives is facilitated by oily components in digestive fluid.

Accumulation of additives in biological tissue was confirmed by feeding experiments

Landfill leachate contain extremely high concentrations of plastic-derived chemicals (additives and/or monomers).

Though not introduced in the talk, debromination (increase in toxicity) of PBDEs is facilitated in anaerobic condition in landfilled garbage.