Overview and scientific evidence on plastics in coastal & marine environment

Shige TAKADA

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

Marine organisms ingest plastics

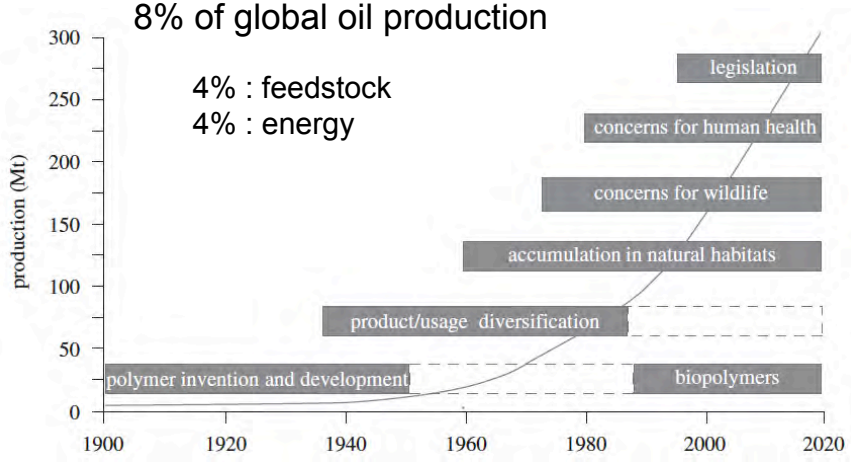
More than 180 species of animals are known to have ingested plastic debris, including birds, fish, turtles and marine mammals.

Physical impacts of the ingested plastics have been reported for many species of organisms (Wright et al., 2013).

Continuous increase in plastic production

8% of global oil production

4% : feedstock
4% : energy



1933:Production of Polyethylene started.

Thompson et al., 2009

Plastic ingestion may lead to decline of the species of seabirds

➡ Endocrine disruption caused by plastic-derived chemicals is of concern.

ABSTRACT

To provide much needed quantitative data on the lethal and sublethal effects of plastic pollution on marine wildlife, we sampled breast feathers and stomach contents from Flesh-footed Shearwater (*Puffinus carneipes*) fledglings in eastern Australia. Birds with high levels of ingested plastic exhibited reduced body condition and increased contaminant load ($p < 0.05$). More than 60% of fledglings exceed international targets for plastic ingestion by seabirds, with 16% of fledglings failing these targets after a single feeding (range: 0.13–3.21 g of plastic/feeding). As top predators, seabirds are considered sentinels of the marine environment. The amount of plastic ingested and corresponding damage to Flesh-footed Shearwater fledglings is the highest reported for any marine vertebrate, suggesting the condition of the Australian marine environment is poor. These findings help explain the ongoing decline of this species and are worrying in light of increasing levels of plastic pollution in our oceans.
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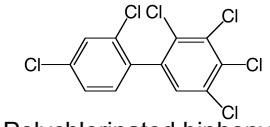
Plastics carry various chemicals in marine environment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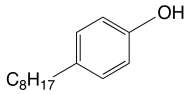
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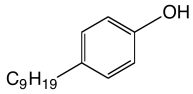
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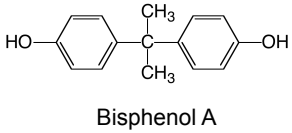
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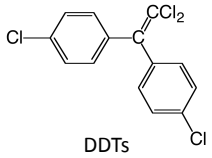
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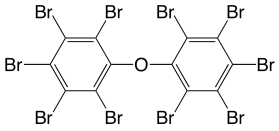
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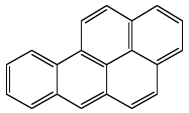
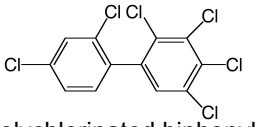

Polycyclic aromatic hydrocarbons (PAHs)

Hirai et al., 2011

Plastics carry two types of chemicals in marine environment

Sorption from ambient seawater

Additive-derived chemicals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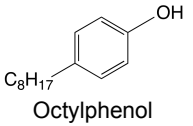
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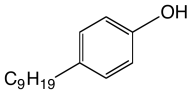
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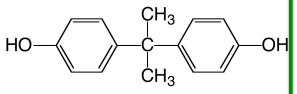
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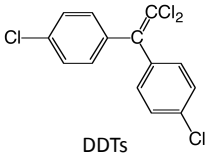
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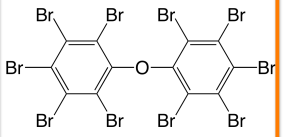
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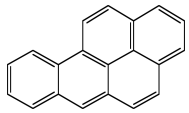
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Plastics carry two types of chemicals in marine environment

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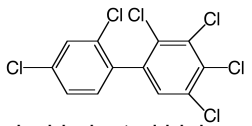
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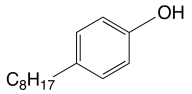
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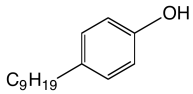
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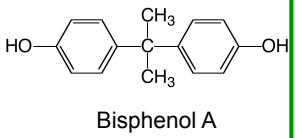
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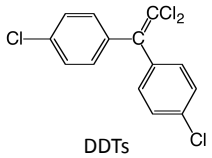
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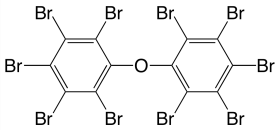
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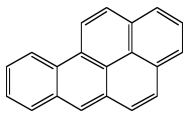
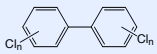

Polycyclic aromatic hydrocarbons (PAHs)

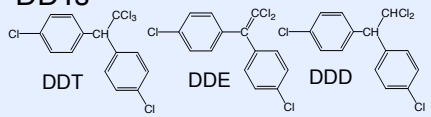
Persistent organic pollutants (POPs)

PCBs



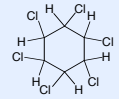
- Industrial products for a variety of uses including dielectric fluid, heat medium, and lubricants.
- Endocrine disrupting chemicals

DDTs


DDT DDE DDD

- DDT and its metabolites such as DDE and DDD.
- DDT was used as insecticides
- Endocrine disrupting chemicals

HCH



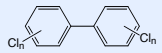
- Insecticide

- ✓Man-made chemicals
- ✓Persistent (stable, resistant to degradation)
- ✓Toxic to human and marine organisms
- ✓Hydrophobic (lipophilic)
- ✓Bioaccumulative

Regulated by Stockholm convention

Pellets accumulate POPs from seawater

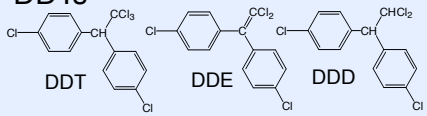
PCBs



・Industrial products for a variety of uses including dielectric fluid, heat medium, and lubricants.

・Endocrine disrupting chemicals

DDTs



・DDT and its metabolites such as DDE and DDD.

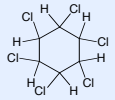
・DDT was used as insecticides

・Endocrine disrupting chemicals

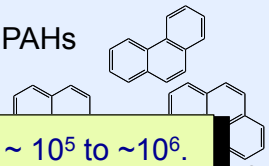
adsorption from ambient seawater

Plastics

HCH



PAHs



Concentration factor is estimated to be ~ 10^5 to ~10^6.

International Pellet Watch

Global Monitoring of Persistent Organic Pollutants (POPs) Using Beached Plastic Resin Pellets

More than 50 pieces (~ 100 pieces) per one location

Laboratory of Organic Geochemistry, Dr. Hideshige Takada, Tokyo University of Agriculture and Technology, Fuchu, Tokyo 183-8509, Japan

International Pellet Watch

Global Monitoring of Persistent Organic Pollutants (POPs) Using Beached Plastic Resin Pellets

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Marine Pollution Bulletin 52 (2006) 1547–1548

MARINE POLLUTION BULLETIN

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Editorial

Call for pellets! International Pellet Watch Global Monitoring of POPs using beached plastic resin pellets

On our beaches, we see various quantities of many materials (e.g., seaweed, driftwood, trash, plastic fragments, cigarette ends) along the high-tide line. Among them, we can commonly find plastic resin pellets. Recently we have started a global monitoring programme of persistent organic pollutants (POPs) using these stranded plastic resin pellets (International Pellet Watch: http://www.tuat.ac.jp/~gaia/ipw/index.html).

Plastic resin pellets are small granules, generally with shape of a cylinder or a disk with a diameter of a few mm (Fig. 1). These plastic particles are the industrial raw material of plastics which are transported to manufacturing sites where "user plastics" are made by re-melting the pellets and molding them into the final products. Resin pellets can be unintentionally released to the environment, both during manufacturing and transport. The released resin pellets are carried by surface run-off, streams and river waters, eventually leading to the ocean. Because of their environmental persistence, they are distributed widely in the ocean and are now found on beaches all over the world. In 2001, we revealed the existence of various organic micropollutants (i.e., polychlorinated biphenyls: PCBs, DDE, and nonylphenol) in these stranded plastic resin pellets collected on beaches (Mato et al., 2001).

Because of the hydrophobic nature of the plastic surfaces, hydrophobic pollutants such as PCBs and DDTs are adsorbed to the pellets from the surrounding seawater with concentration factors of up to 10^6. We observed a weak correlation between PCBs concentrations in plastic resin pellets collected on beaches with levels in traditional monitoring media (i.e., mussels), although large piece-to-piece variability of PCB concentrations was also observed (Endo et al., 2005). Because the resin pellets are distributed on beaches the world over, and because collection and shipping of the pellets are easy, we propose global monitoring of persistent organic pollutants (POPs) using these beached plastic resin pellets.

In the International Pellet Watch project, we ask people from all countries to collect plastic resin pellets on their nearby beaches and send them to our laboratory via air-mail. No cooling nor freezing is necessary during shipment. People just need to put the pellets into a paper envelope and post it to us. To get representative data, we need 100–200 pieces of pellets (preferably yellowed pellets) from each location. Organic micro-pollutants in the pellets will be analyzed in our laboratory. Based on the analytical results, global distributions of these organic micro-pollutants will be mapped. Results will be sent to the participants through e-mail and will be released on the web as well.

The purpose of International Pellet Watch is to understand the current status of global POPs pollution, and the advantage of Pellet Watch is its extremely low cost of sampling and shipping as compared with conventional monitoring using water, sediment and biological samples. Further, we can draw global POPs pollution maps for a very low cost. Already several NGOs who conduct beach clean-up projects are helping with sample collection.

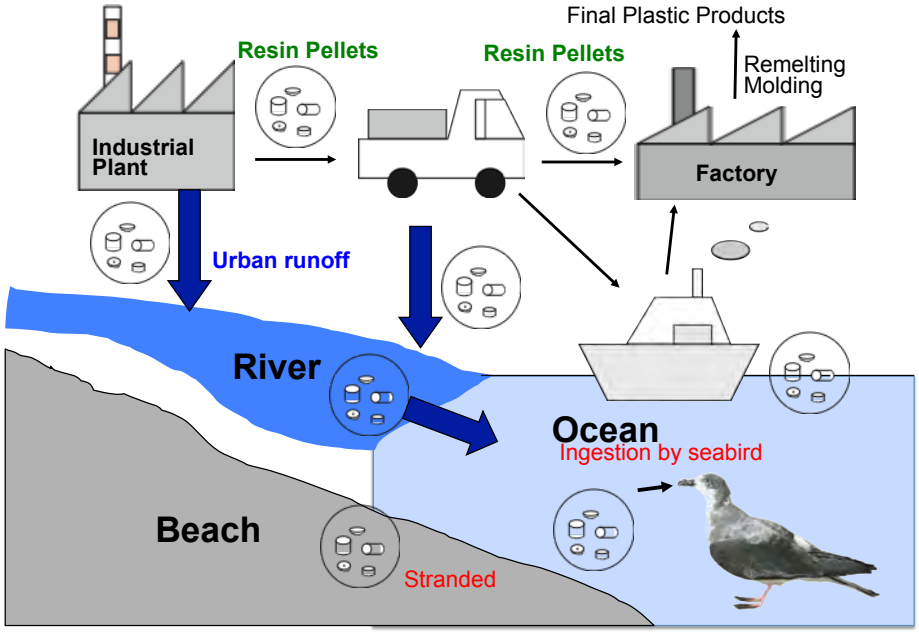
So far, our spatial coverage is very limited and of course the strength of the programme will be related to the coverage

Fig. 1. Plastic resin pellets.

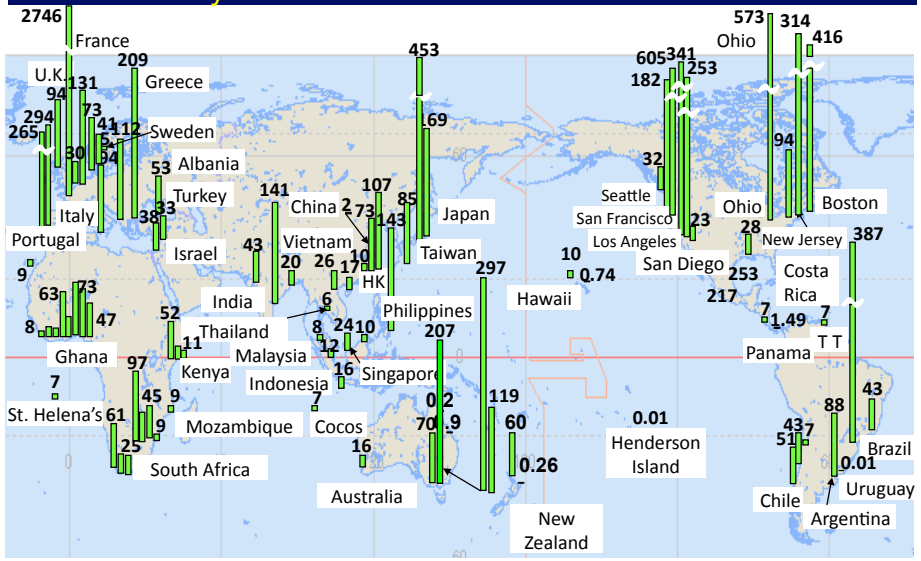
0025-326X/$ - see front matter © 2006 Elsevier Ltd. All rights reserved.
doi:10.1016/j.marpolbul.2006.10.010

Since 2005

Resin pellets, industrial feedstock of user plastics, are spilled during transport and manufacturing and they are widely distributed in the ocean



International Pellet Watch : monitoring of POPs
Plastics carry hazardous chemicals in marine environments



Concentration of PCBs* in beached plastic resin pellet (ng/g-pellet)

Marine Pollution Bulletin 62 (2011) 2845–2849

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Baseline

Edited by Bruce J. Richardson

The objective of BASELINE is to publish short communications on different aspects of pollution of the marine environment. Only those papers which clearly identify the quality of the data will be considered for publication. Contributors to Baseline should refer to 'Baseline—The New Format and Content' (*Mar. Pollut. Bull.* **60**, 1–2).

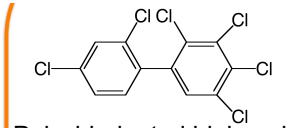
Physical and chemical effects of ingested plastic debris on short-tailed shearwaters, *Puffinus tenuirostris*, in the North Pacific Ocean

Rei Yamashita [a,c,*], Hideshige Takada [a], Masa-aki Fukuwaka [b], Yutaka Watanuki [c]

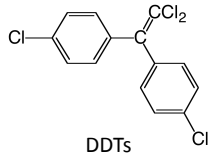
[a] *Laboratory of Organic Geochemistry (LOG), Tokyo University of Agriculture and Technology, Fuchu, Tokyo 183-8509, Japan*
[b] *Hokkaido National Fisheries Research Institute, Fisheries Research Agency (FRA), 116 Katsurakoi, Kushiro, Hokkaido 085-0802, Japan*
[c] *Graduate School of Fisheries Sciences, Hokkaido University, 3-3-1 Minato, Hakodate 041-8611, Japan*

Plastics carry two types of chemicals in marine environment

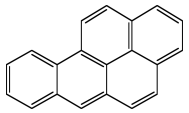
Sorption from ambient seawater



Polychlorinated biphenyl (PCBs)

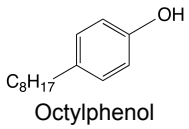


DDTs

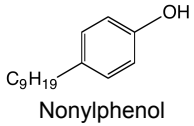


Polycyclic aromatic hydrocarbons (PAHs)

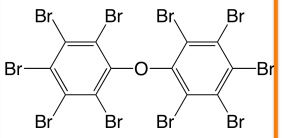
Additive-derived chemicals



Octylphenol



Nonylphenol



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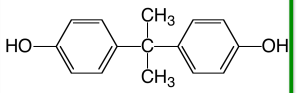

Bisphenol A

Increased pollutants concentrations with increasing plastic ingestion

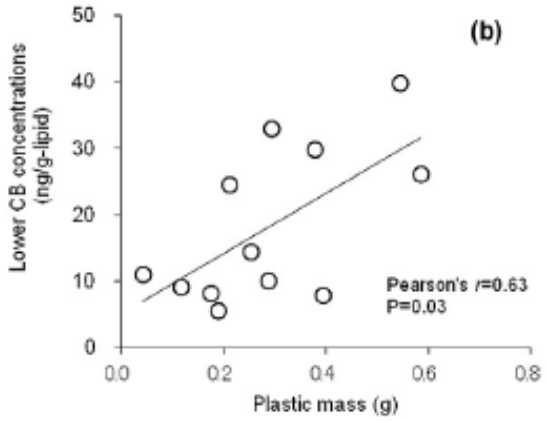

Fig. 4. Relationships between ingested plastic mass and concentrations of (a) total PCBs, (b) lower-chlorinated congeners (Cl number 2–4, see Fig. 3), and (c) higher-chlorinated congeners (Cl number 5–9, see Fig. 3) in abdominal adipose tissues of shearwaters that ingested plastics.

Faculty of 1000

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Baseline

Accumulation of plastic-derived chemicals in tissues of seabirds ingesting marine plastics

Kosuke Tanaka [a], Hideshige Takada [a,*], Rei Yamashita [a], Kaoruko Mizukawa [a], Masa-aki Fukuwaka [b], Yutaka Watanuki [c]

[a] Laboratory of Organic Geochemistry (LOG), Tokyo University of Agriculture and Technology, Fuchu, Tokyo 183-8509, Japan
[b] Hokkaido National Fisheries Research Institute, Fisheries Research Agency, Kushiro, Hokkaido 085-0802, Japan
[c] Faculty of Fisheries, Hokkaido University, Hakodate, Hokkaido, Japan

ARTICLE INFO

Keywords:
Polybrominated diphenyl ethers (PBDEs)
Plastic debris
Additives
North Pacific Ocean
Short-tailed shearwater
Bioaccumulation

ABSTRACT

We analyzed polybrominated diphenyl ethers (PBDEs) in abdominal adipose of oceanic seabirds (short-tailed shearwaters, *Puffinus tenuirostris*) collected in northern North Pacific Ocean. In 3 of 12 birds, we detected higher-brominated congeners (viz., BDE209 and BDE183), which are not present in the natural prey (pelagic fish) of the birds. The same compounds were present in plastic found in the stomachs of the 3 birds. These data suggested the transfer of plastic-derived chemicals from ingested plastics to the tissues of marine-based organisms.

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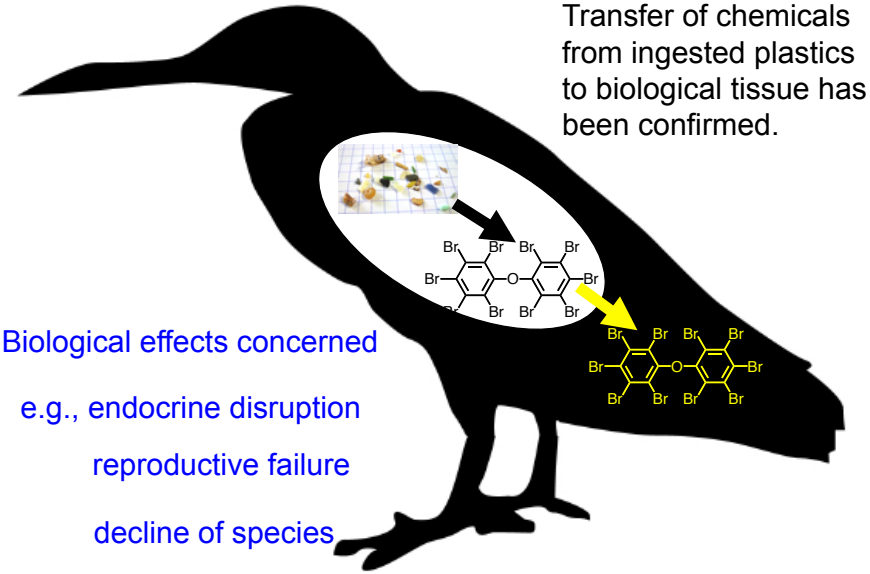
Transfer of chemicals from ingested plastics to biological tissue



Transfer of chemicals from ingested plastics to biological tissue has been confirmed.

Biological effects concerned

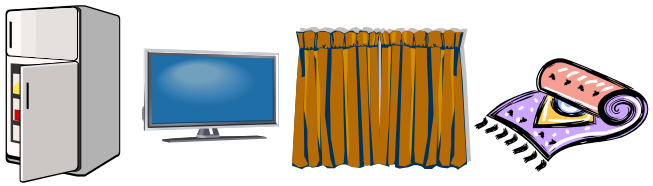
e.g., endocrine disruption

reproductive failure

decline of species

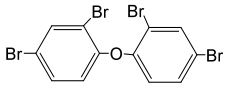
PBDEs : Flame retardants

applied in various electric products and fabrics.



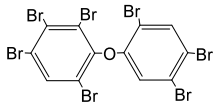
3 technical products (mixtures of congeners)

Penta BDE
(Br4, Br5)



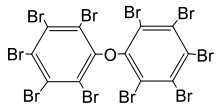
e.g., BDE47

Octa BDE
(Br7,8)



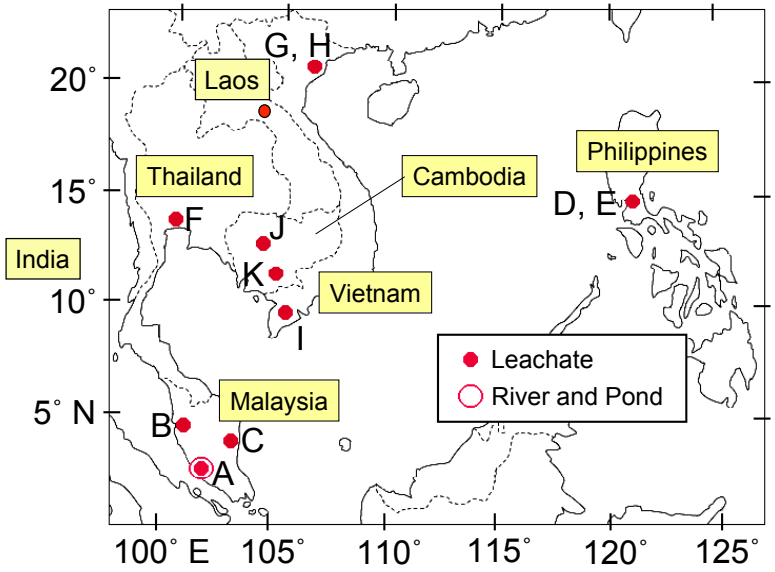
e.g., BDE183

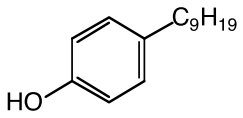
DecaBDE
(Br10)



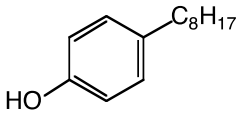
e.g., BDE209

Sampling locations of Leachate samples from Land-fill sites

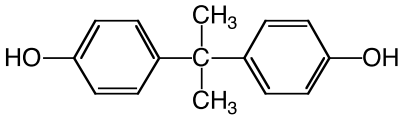




Nonylphenol (NP)



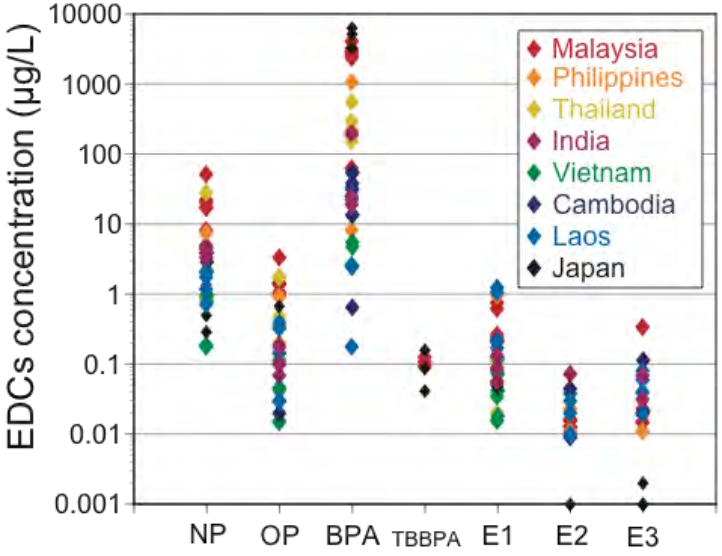
Octylphenol (OP)



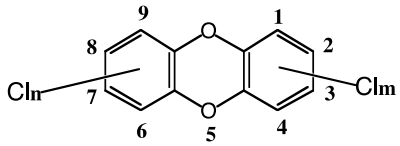
Bisphenol A (BPA)

Plastic-derived Phenolic endocrine disrupting chemicals (EDCs)

EDCs concentrations in leachate samples from Tropical Asian countries



Incineration of plastics with halogen generates toxins such as dioxins



n+m = 1 - 8

Polychlorinated dibenzo-*p*-dioxins (PCDDs; Dioxins)

75 congeners

Construction, operation, maintenance, and final disposal of incinerators take huge cost

If we would pay 100 million USD, we can avoid dioxine pollution. However, can we pay if forever? Accident may discharge toxins to surroundings.

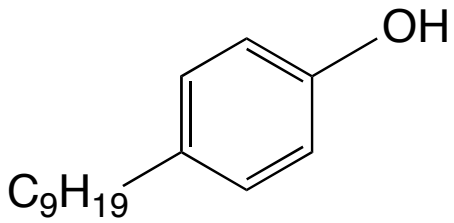
Do you prefer this cost and risk rather than recycling-oriented society?

3R

Reduce
Reuse
Recycle

No single-use plastic!

Nonylphenol : Endocrine disrupting chemicals



Additives to plastic

Antioxidants
Antistatic agents

- disorders in the reproductive system
- vaginal clear cell adenocarcinoma
- decreased ability to reproduce

3R

Reduce

Reuse : non-reusable plastics
Recycle : consumes energy and produces CO_2

No single-use plastic!

Laboratory of Organic Geochemistry
Dr. Hideshige Takada,
Tokyo University of Agriculture and Technology,
Fuchu, Tokyo 183-8509, Japan

More than 50 pieces (~100 pieces) per one location

Sorting

PE, yellowing pellets

Analysis for POPs (PCBs, organochlorines, PAHs)

By GC-MS/MS, GC-MS, GC-ECD
more than 5 pools of 5 pellets
to exclude sporadic high concentration

Mapping POPs pollution

http://www.pelletwatch.org/

- **Feed the data** back to the collaborators via e-mail
- **Releasing** the results on **web**