Global distribution of organic micropollutants in marine plastics

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1. Introduction

Marine plastics including plastic fragments and plastic resin pellets are distributed widely in the ocean. Because the marine plastics contain organic pollutants [1], their adverse effects have been of great concern. To assess the risks of plastic-associated chemicals, understanding of concentration range of chemicals detected in marine plastics and their spatial variation is necessary. Only limited information has been available on the concentrations of organic micropollutants in the marine plastics [2]. In the present study, plastic fragments were collected from urban and remote beaches and open oceans and analyzed for wide range of chemicals. To understand the global distribution of the pollutants in marine plastics, plastic resin pellets collected from 51 beaches of 23 countries were also analyzed for polychlorinated biphenyls (PCBs) and the other hydrophobic pollutants.

2. Materials and Methods

Plastic fragments (~ 10 mm) were collected from open ocean (Pacific Ocean and Atlantic Ocean), remote coast (Costa Rica and Tonkin Bay) and urban coasts (Japan and USA). The fragment samples from the open oceans were collected by neuston net. The coastal fragment samples were collected on sandy beaches by stainless steel tweezers or fingers. Beached plastic resin pellets were collected by local volunteers at 51 locations of 23 countries. Plastic samples were sorted using near-infrared spectrometer (Plascan-WTM OPT Research Inc, Tokyo, Japan) into polyethylene (PE) and polypropylene (PP) and other polymers. Both polyethylene and polypropylene fragments were analyzed, while only PE was analyzed for the pellet samples. The sorted plastics were extracted with organic solvents. The extracts were fractionated by using silica gel column chromatography. Hopanes, PCBs, polycyclic aromatic hydrocarbons (PAHs), organochlorine pesticides (DDTs, HCHs), polybrominated diphenyl ethers (PBDEs), alkylphenols and bisphenol A (BPA) were determined by using gas chromatograph equipped with mass spectrometer (GC-MS). To understand piece-to-piece variability and estimate the representative concentrations of the pollutants at individual beaches, multiple (2 to 5) pools were analyzed for each location. The details of the analytical procedure are available in our previous paper [3].

3. Results and Discussion

PCBs, DDTs, PAHs, PBDEs, nonylphenol, octylphenol and BPA were detected in the plastic fragment samples with concentration range from ng/g to μg/g, as shown in Fig.1. Hydrophobic contaminants sorbed from seawater showed higher concentrations in PE fragments than PP fragment. This is probably due to more hydrophobic nature of PE. PCB concentrations in polyethylene fragments from the urban coasts (Tokyo, Kanagawa and Long Beach) were much higher than those from the North Central Pacific Gyre, Atlantic Ocean, Costa Rica coast, and Vietnamese coast. This regional pattern reflects a difference in PCB usage, with larger amounts of PCBs used in the USA and Japan, and minimal usage in Costa Rica and Vietnam. Emitted PCBs have accumulated in coastal zones, particularly in sediments, which are likely to be resuspended into the water column. Furthermore, this spatial pattern and concentrations of PCBs in the plastic fragments were positively correlated with the analytical results of PCBs in the plastic resin pellets collected from the same beaches (n=5, r^2 = 0.90), indicating that toxicological risks of hydrophobic pollutants in plastic fragments, which are more abundant in the ocean, can be estimated from the analytical results of

plastic resin pellets (i.e., *International Pellet Watch* [3]). As shown in Fig.2, PCB concentrations of beached plastic resin pellets were highest on the coasts of USA, followed by Japan and Europe. In Latin America, tropical Asia, Australia, and Africa, PCB concentrations were much lower. This is again due to legacy of PCB pollution. These results indicated that potential threat associated with PCBs in marine plastics would be more serious in urban coasts than open ocean and remote beaches. However, even in the open ocean and the remote coast, high concentrations of additive-derived chemicals, such as nonylphenol and decabrominated diphenyl ether (BDE209), were detected from plastic debris, especially polypropylene fragments (Fig.1). High concentrations of nonylphenol over 100 ng/g with maximum concentration of 3900 ng/g were detected in plastic fragments from Atlantic and Pacific Oceans and Costa Rica coast. BDE209 over 10000 ng/g was detected in a polypropylene fragment from the Pacific Gyre. In the open oceans and remote coast, ecological risk associated with plastic additives could be more serious than chemicals sorbed from seawater.

4. References

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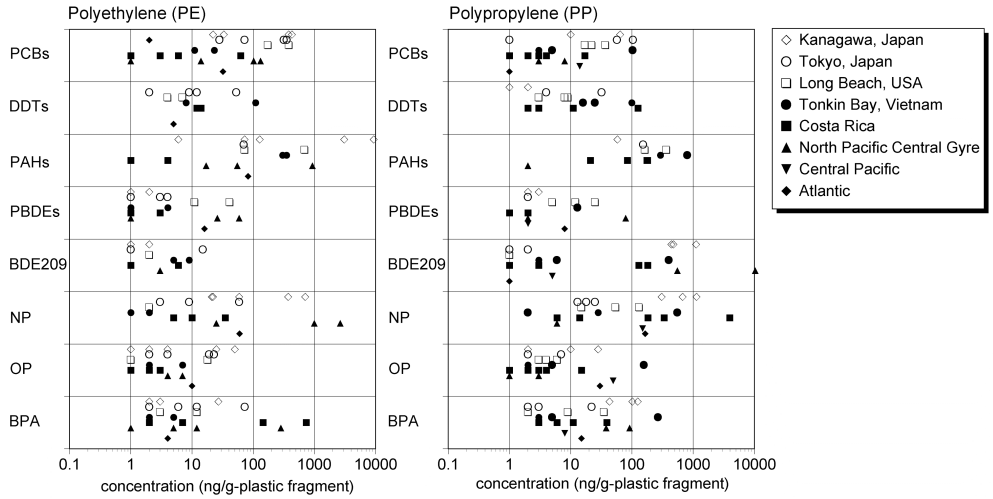

Figure 1. Concentrations of organic pollutants in marine plastic fragments.

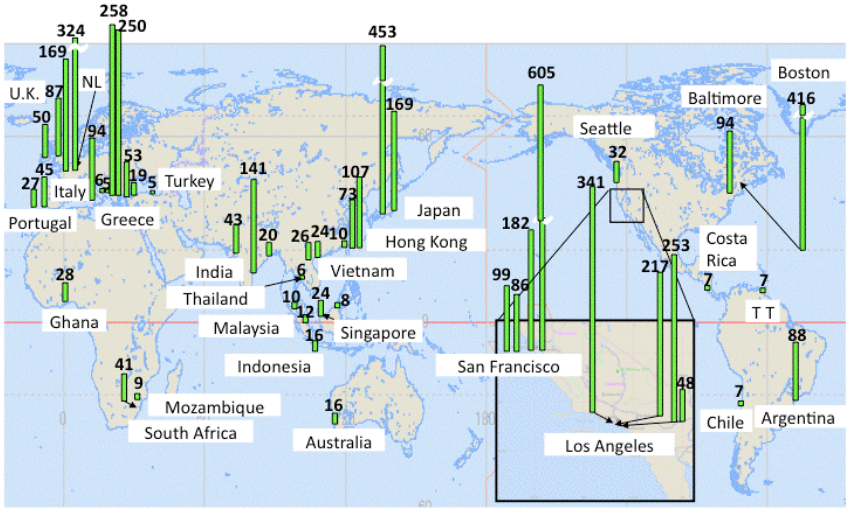

Figure 2. PCB concentrations in plastic resin pellets.