Hazardous chemicals in deep-sea plastic garbage collected from the West Pacific Ocean

○Nurlatifah, Takuya Yamauchi (Kumamoto Univ.), Ryota Nakajima, Masashi Tsuchiya, Akinori Yabuki, Tomo Kitahashi, Yuriko Nagano, Noriyuki Isobe (JAMSTEC), Haruhiko Nakata (Kumamoto Univ.)

Introduction

In recent years, we have been living in "plastic age" when plastic products are massively produced and more favorable due to its low-cost, lightweight, and durable nature. Assuming to its purpose, each plastic product has different lifespan. Chemical additives play a great role in improving and modifying physical as well as chemical properties of plastic materials (Wagner and Schlummer, 2020). Plastic additives include plasticizers such as dibutyl phthalate (DBP), benzyl butyl phthalate (BBP), diisobutyl phthalate (DiBP), bis (2-ethylhexyl) phthalate (DEHP), and other phthalates which are included in candidate list for substance of very high concern (SVHC) (European Chemical Agency, 2020). Antioxidant such as butylated hydroxy toluene (BHT) and flame retardant such as triphenyl phosphate (TPhP) are also generally added to plastic products. As some plastic additives are only mixed and weakly bond to the polymer (Alaee et al., 2003), it raise concern as it may leach to the environment not to mention marine environment. Approximately 4.8 to 12.7 million MT plastic waste was estimated entering the ocean (Jambeck et al., 2015). Only 0.1%-1.25% of number of plastic input to the ocean (Ritchie and Roser, 2018) was found floating in the concentrated gyres which implies around 99% of missing plastic might be sinking to deeper layer of ocean.

Known to be transporting marine debris originated from Asia to North Pacific Subtropical Gyre, Kuroshio Extension (KE) and Kuroshio Extension Recirculation Gyre (KERG) are flowing eastward between 140°-180°E and have high intensities of eddy interaction. Thus, KE/KERG has higher possibilities to retrain and sunk plastic debris into sub-surface layer (Nakajima et al., 2020). So far, there are some studies that report the abundance of plastic debris in deep-sea floor, but actual concentration of additives that contained in those plastic debris are poorly understood.

Materials and Methods

A total of twenty-one plastic debris samples were collected from deep-sea floor of Sagami Bay and West Pacific Ocean under KE/KERG (water depth: 1,388-5,819 m) during a research cruise abroad of R/V *Yokosuka* (YK 19-11) in August–September 2019. These plastic samples were classified into 6 categories which are plastic bag, plastic package, plastic sheet, clothes, rope and can based on its shape, materials and some printing on the surface. Polymer type of plastic samples was first identified using (ATR) FT-IR (IR Affinity IS, Shimadzu, Japan) after all organic matter were decomposed by using 30% hydrogen peroxide. While all samples used for chemical analysis did not treated with hydrogen peroxide to avoid elution of plastic additives from products. Ten to sixty mg of plastic samples were extracted by 1 mL of dichloromethane using ultrasonic instrument (15 min) for 3 times. Surrogate standards mixtures (final concentration: 100 µg/L) of six deuterated phthalates (d_4-DMP, d_4-DEP, d_4-DiBP, d_4-DBP, d_4-BBP, d_4-DEHP) was spiked into solution. The liquid phase was collected and concentrated using nitrogen stream. 1-methyl naphthalene-d_{10} was spiked as internal standard (final concentration: 50 µg/L). Plastic

additives concentration was then determined by using 7890A gas chromatograph coupled to a 5975C mass spectrometer (Agilent Technologies, Santa Clara, CA, USA) with SIM mode.

Results and Discussion

Results from FT-IR analysis revealed that polyethylene (PE) was dominant polymer (57% of the total) in samples, followed by polyvinylchloride (PVC), epoxy resin, polyester (PES), and polypropylene for 10%, 10%, 9%, and 9% respectively. As for plastic additives, bis (2-ethylhexyl) phthalate (DEHP) was detected to be contained in a PVC sheet at concentration of 48%. Antioxidant of butylated hydroxytoluene (BHT) was also detected and being dominant in PE plastic debris with median concentration of 12,000 ng/g. PES clothes were detected to contain dyeing mixtures, 1,2,4-trichlorobenzene (1,2,4-TCB), up to 42,000 ng/g. Knowing estimated number of plastic debris under KE current which is as high as 6.5 billion items in the seafloor of a total area of 1,420,000 km^2 (Nakajima et al., 2020), the burden of chemical additives were estimated that 720 kg of dibutyl phthalate, 570 kg of BHT, 230 kg of DEHP, and 160 kg of 1,2,4-TCB exist on the seabed of KE/KERG zone (Fig. 1). This result strongly suggests that great threat of marine life lies within plastic debris on abyssal level of the ocean.

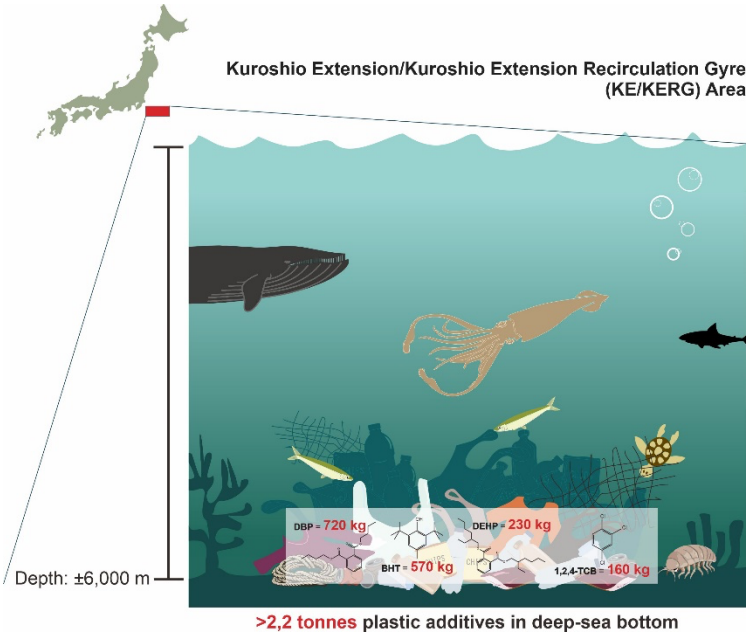

Fig. 1 Chemical additives burden in deep-sea floor of KE/KERG current area

Acknowledgements

The authors sincerely thank the Captain and the crew of R/V *Yokosuka* and *Shinkai 6500* for their great efforts to sample collection. This study is partly supported by the Japan Society for the Promotion of Science (JSPS) KAKENHI grant number 19K12372, and SATREPS supported by Japan Science and Technology Agency (JST).

Reference

1) Alaee, M. *et al.* (2003) *Environment International* 29, 683–689.
2) European Chemical Agency, Substance Infocard for Bis(2-ethylhexyl) phthalate. https://echa.europa.eu/substance-information/-/substanceinfo/100.003.829 (accessed Oct 17, 2020)..
3) Jambeck, J. *et al.* (2015) *Science* 347, 768–771.
4) Nakajima, R. *et al.* (2020) *Scietific Reports* (Submitted)
5) Ritchie, H. *et al.* (2018) Plastic Pollution, https://ourworldindata.org/plastic-pollution#citation. (accessed Oct 17, 2020).
6) Wagner, S. *et al.* (2020) *Resource, Conservation, and Recycling* 158, 104800.