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Marine plastics and microplastics: Threat to marine ecosystem

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On global basis, 300 millions tons of plastics are produced annually. Half of them are single-use plastics. Some of them escape from waste management on land and discharged to rivers and finally to the ocean. The amount of plastics entering to the ocean is estimated at millions tons per year (i.e., 5 – 13 millions tons/y, Jambeck et al., 2015). During their floating on sea surface and/or stranding on beaches, they are exposed to UV radiation and get fragmented into smaller plastics. Fragments get smaller and smaller and finally they become microplastics (i.e., plastics less than 5 mm). Plastics are hardly biodegraded and persist in marine environments for a long time. Therefore, huge number of plastics (i.e., 5 trillions pieces, Eriksen et al., 2014) are floating on world ocean ranging from Arctic (Obbard et al., 2014) to Antarctic (Isobe et al., 2016). Higher abundance of microplastics in western pacific has been recently revealed (Isobe et al., 2015)

Plastic fragments in the ocean are ingested by various sizes of marine organisms depending on the sizes of plastic fragments. Ingestion of larger items (e.g., ~ cm) by large marine organisms such as whales, sea turtles, and seabirds has been often reported since 1970s (e.g., Rothstein, 1973). Recently, ingestion of smaller plastics, i.e., microplastics, by shellfish (e.g., Li et al., 2015) and fish (e.g, Lusher et al., 2013) was reported. For example, ~ 80 % of anchovies taken from Tokyo Bay, Japan, contained ~ 1 mm microplastics in their digested tracts (Tanaka and Takada, 2016). Nowadays, more than 200 species of marine organisms have been reported to ingest plastics. They give physical damages on the biota (Wright et al., 2013).

In addition, marine plastics and microplastics contain hazardous chemicals and may give chemical threat to marine organisms (Rochman et al., 2013). Most of plastic products (i.e., user plastics) contain additives such as plasticizers, antioxidants, flame retardants to maintain their properties. The additives are still retained in microplastics collected from marine environment, even open ocean (Hirai et a., 2011), though additives, especially hydrophilic ones, are leached to seawater during floating of the microplastics. Furthermore, microplastics sorb and accumulate persistent organic pollutants (POPs) from surrounding seawater. International Pellet Watch (http://www.pelletwatch.org/) has been demonstrating the accumulation of POPs in microplastics on beaches across the world (Ogata et al., 2009; Takada and Yamashita, 2016). Furthermore, transfer of hazardous chemicals from ingested plastics to internal tissue (adipose and liver) has been demonstrated (Teuten et al., 2009; Yamashita et al., 2011; Tanaka et al., 2015; Wardrop et al., 2016).

Microplastics are originally floating on sea surface but some of them sink to the bottom following the attachment of biofilm on microplastics (Zettler et al., 2013) which gives settling

force to the microplastics. Microplastics were detected in bottom sediments (Van Cauwenberghe et al., 2013; Takada et al., in preparation) and they could be sink of microplastics in marine environments. Dynamic transport processes (e.g., fragmentation, lateral transport, sedimentation, resuspension) of microplastics in marine environments should be systematically studied. Furthermore, sediment cores can be utilized as historical recorder or archives of microplastics pollution in marine environments. We analyzed microplastics in layers of sediment cores collected from Japan (Moat in Tokyo), Thailand (Gulf of Thailand), Malaysia (Straits of Johor), Vietnam Tonkin Bay), and South Africa (Durban Bay). For all the sediment cores, increasing trends of microplastic concentrations from deeper layers to surface layers were observed. These profiles provide solid evidence that microplastic pollution is getting serious on global basis. These also mean that record of human activities (i.e., mass usage of synthetic polymers) is inscribed in geological media and are an indication of Anthropocene (Waters et al., 2016). Risks of microplastics to marine ecosystem and human have been suggested by recent studies but their full understanding has not been achieved and is mission of oceanographers. However, microplastics are persistent in marine environment and we cannot remove them. Thus, as precautionary principle, we need to reduce the inputs of plastic wastes to the sea.