Long-term trend in sedimentation flux of microplastics in Beppu Bay from 1940s

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To comprehend and predict the adverse effects of various sizes of marine plastics on the marine environment, it is necessary to estimate the standing stock of all categories of marine plastics (micro- (<5 mm), meso- (5–25 mm), and macroplastics (>25 mm); Lee et al., 2013; Romeo et al., 2015) in the marine reservoirs, namely, beach sediments, sea surfaces, water columns, bottom sediments, marine biota, and the fluxes between them (Hardesty et al., 2017). Larger plastics are likely to wash ashore (Isobe et al., 2014), stay longer on beaches and undergo photo-oxidative degradation and gradual fragmentation. Once plastics have fragmented, they are likely to be trapped by swash waves and returned to the coastal seas (Hinata et al., 2017). Beaches are "manufacturing plants" of microplastics. And, recently, it has been found that microplastics are likely to sink to the coastal sea bottom (Claessens et al., 2011; Vianello et al., 2013; Matsuguma et al., 2017; Sagawa et al., 2018; Brandon et al., 2019). The bottom sediments are "a storage medium" for the status of the marine plastics pollution from past to present, which help us to predict deductively the future trend of the pollution with numerical simulations. However, despite the increased awareness of the bottom sediments as a microplastic reservoir, the sedimentation fluxes of microplastics have not been fully examined due to the difficulty in dating the bottom sediments in the coastal seas. In this study, sedimentation fluxes of microplastics from 1940s have been estimated by analyzing 10 sediment cores sampled from a Japanese hypoxic coastal water.

Beppu Bay is a small embayment, which is located in the western part of the Seto Inland Sea. A stable hypoxic condition in the deepest part of the bay (h=70 m) suppresses the bio-perturbation (vertical mixing of sediment layers) and thus enable us to date the bottom sediment (e.g., Kuwae et al, 2013). We have collected 10 sediment cores from the deepest part of the bay by using two types of gravity corer in 2017 and 2018. Nine sediment cores were used for microplastic analysis, and one was for dating sediment layers. Microplastics extracted from the sediment core samples were analyzed by FT-IR to identify the polymer type. The sedimentary age was determined by using the Pb-210 method and validated by computed tomography scanning images and magnetic susceptibility measurements.
A total of 183 pieces of microplastic were detected from nine sediment samples. Representative polymer types of the extracted microplastics were polystyrene (PS), polyester (PE), polypropylene (PP). The most common polymer type among plastics was PE which accounted for 54% of the total in contrast to the bottom sediment in Hiroshima Bay (Sagawa et al., 2018), where the foamed polystyrene microplastics were dominant (79%) mainly originated from aquaculture facilities. Generally, the numerical flux of microplastics has been increasing exponentially from 5 [pieces/m^2·y] in 1940s to 205 [pieces/m^2·y] in 2010s as well as the flux in weight from 0.46 [mg/m^2·y] in 1940s to 7.43 [mg/m^2·y] in 2010s. The numerical flux in 2010 was 162 [pieces/m^2·y], which is about 1/7–1/8 of that from Santa Barbara Basin in 2010 (Brandon et al., 2019). The long-term trend in fluxes have close correlation with the standing stock of plastics in Japan, while the correlation with domestic production of plastics, which has reached the ceiling in the late 1990s, was rather small.

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