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# Marine neustonic microplastics around the southeastern coast of Korea

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ABSTRACT

We investigated floating debris around the mouth of the Nakdong River in the Southeastern Sea of Korea using a Manta trawl (330-μm mesh) and hand-net (50 μm) before (May) and after (July) the rainy season in 2012. Microplastic (<2 mm) was present at all of the stations, whereas Styrofoam (2–5 mm) peaked only at a few stations far from the Nakdong River mouth in July. The dominant types were fibers (polyester), hard plastic (polyethylene), paint particles (alkyd), and Styrofoam (expanded polystyrene). The average abundances of fibers and hard plastic (<2 mm) in the trawl were significantly higher in July than in May ($p < 0.005$, $p < 0.05$, respectively), while two orders of magnitude more microplastics (<2 mm) were collected with the hand-net than with the trawl. Fibers and hard plastic by trawl were significantly compared temporally, and the hand-net proved the missed microplastics (50–330 μm) when trawl used.
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## 1. Introduction

Plastics are used widely in all aspects of human life due to their versatile properties that make them suitable for manufacturing commercial products (Derraik, 2002). Some plastics are initially buoyant, so floating plastic debris has dispersed globally as the result of long-distance drifting in ocean currents (Derraik, 2002; Ryan et al., 2009). Due to their strong resistance to degradation after entering marine environments, plastics pose long-lasting danger to birds and marine mammals in terms of entanglement, choking, and a pseudo sense of fullness after ingestion (Laist, 1987; Shaw and Day, 1994; Boerger et al., 2010; Murray and Cowie, 2011; Hong et al., 2013; Lee et al., 2013b). Most studies on marine debris have focused on large, visible plastics on beaches and the seabed (Derraik, 2002). The same hazards can occur in microorganisms, but have not been proved due to lack of scientific evidences. The generable possibility of physical impacts by microplastics to marine invertebrates was only suggested in terms of blocking feeding appendages of marine invertebrates and clogging the alimentary canal of small sized invertebrates (Wright et al., 2013).

Plastic materials reach the sea from two main sources: from sea-based sources, such as dumping and accidental loss from ships and from land-based sources, such as river runoff and municipal drainage systems (Derraik, 2002; Ryan et al., 2009). The distribution of plastic debris at sea is very heterogeneous for a variety of reasons, including the prevailing surface circulation and winds, coastline geography, and the points of entry into the marine environment (Barnes et al., 2009; Doyle et al., 2011). Going from coastal to offshore waters, the total litter load decreases, whereas the proportion of ship-based litter increases. The combination of the above-mentioned multiple inputs and diffuse factors could result in spatiotemporal variability in the distribution of floating plastic in surface waters (Ryan et al., 2009).

Recently, concern has increased regarding the ecological impact of microplastic, as smaller pieces of plastic debris occur widely in marine environments (Andrady, 2011). The two main sources of these small particles consist of primary microplastic particles manufactured to be of microscopic and mesoplastic size for use as scrubbers, exfoliating cleansers in cosmetics, and air-blasting cleaning media (Cole et al., 2011), and secondary microplastics resulting from the breakdown of larger plastic items (Thompson et al., 2004).

Microparticles can fall within the size range of phytoplankton, which are the major food items of zooplankton, but also the size range of zooplankton. Consequently, microplastic is readily ingested by filter-feeders or higher-level predators, and negative impacts of microplastic at the base of the marine food chain are

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likely (Moore et al., 2001; Andrady, 2011). Accordingly, concern is growing regarding the effects of floating debris in the marine environment at oceanographic convergences, where floating particles accumulate naturally and high contact rates between live organisms and micro-debris are expected.

To clarify the potential confusion of microplastic particles with plankton by filter-feeders or predators resulting from the accumulation of plastic debris at sea, the abundance, distribution, and composition of floating microparticles should first be explored. Understanding the distribution of floating micro-debris is prerequisite for the study of its environmental effects on planktonic organisms of similar size to microplastic. However, little is known about the occurrence and abundance of floating microplastics in the coastal areas of Korea.

Therefore, this study first investigated the abundance and composition of floating microplastic in the southern coastal waters of Korea during the dry period and shortly after the rainy season. The study area was located at the mouth of the Nakdong River, the second longest river in Korea, which passes through an area with a high population density and many industrial facilities. This survey can provide fundamental information for elucidating the current status and distribution pattern of floating debris for further study on the effects of debris on plankton or plankton feeders in the study area.

## 2. Methods and materials

### 2.1. Study area

The survey area is located in coastal and offshore waters spanning a sphere of Nakdong River mouth's influence and the farthest stations are 42 km far from Nakdong River mouth (Fig. 1). The river's mouth is the estuary of Nakdong River, which is the second largest river ecosystem (catchment area: ca. 23,817 km$^2$) as one of Korea's four major river systems. Along the Nakdong River, a variety of industrial complex and intensive utilization of agricultural land were situated for use of industrial and agricultural water, and cities including about ten million people utilize it as a source of drinking water. And the discharge volume from Nakdong river-mouth weir has been controlled by opening and closing the sluice gates for flood control (Kim et al., 1999; Lee and Kim, 2007; Yoon et al., 2008).

### 2.2. Samplings

Floating microplastics were collected around Nakdong River mouth in the Southern Sea of Korea during dry period of 29–30 May and 23–24 July after rainy season in 2012 using a Manta-trawl net with 330-μm mesh and a hand-net with 50-μm mesh (Fig. 1). Sampling for microplastics using both the nets was conducted at same sampling stations (Fig. 1). Samples were collected with a Manta trawl net which had 0.4 × 0.195 m rectangular opening and 3 m long 330-μm mesh net, and a hand-net with mouth diameter of 0.2 m and 0.6 m long 50-μm mesh. The trawl was askew towed from the stern at surface waters outside of effects of bow wave for about 10 min at an average vessel speed of approximately 1.5–2.5 knots. After recovery of the net from sea, the net was carefully washed from the outside to confirm that all debris was washed into the cod-end bucket. Contents of the buckets were reduced and transferred into a sample bottle of 1 L. The concentrated sample bottles were stored under the condition of 4 °C and moved into the laboratory. The volume filtered by the net was calculated to cubic meters based on the readings of a flowmeter (Hydro-Bios Model 438-115) fixed at the mouth of the net frame. Additional samplings were carried out with a hand-net to understand abundance and characteristics of 50 μm–2 mm size range microplastics compared to 330 μm–2 mm by a Manta trawl. Bulk seawater (100 L) was repeatedly collected with a hand beaker (5 L) at less than 20 cm depth (not to over 20 cm beaker mouth) surface waters. And the collected surface water (100 L) was passed through the hand-net and concentrated into the 1 L sample bottle. The samples were also moved into the laboratory and treated according to the same condition to that of Manta trawl samples.

### 2.3. Plastic analysis

We selected use of sieve of 2 mm mesh size other than 1 mm for further size separation because samples collected by the trawl were not easily run through sieve of 1 mm mesh sizes due to intermingled land and marine-based organic debris, especially gelatinous materials. Before separating microplastics from samples (1 L) with sieve of 2 mm mesh sizes, larger particles than roughly 2 mm such as plastic and non-plastic materials were first picked out from the sample bottles. Intermixed plastics, which can be

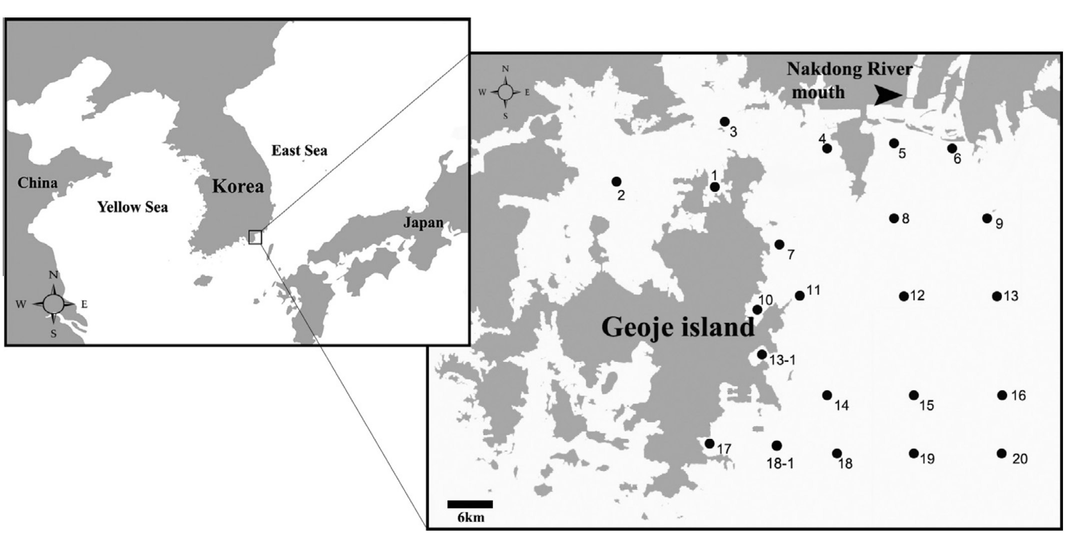


**Fig. 1.** Map showing the stations near the Nakdong River mouth on the southeastern coast of Korea sampled using a Manta trawl and hand-net.

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