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Abundance of plastic microbeads in Hong Kong coastal water

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A B S T R A C T

To address the rising concern over the use of plastic microbeads in personal care and cosmetic products, countries worldwide have started taking legislative actions to ban microbeads. Yet, the degree of contamination of coastal waters by plastic microbeads is rarely reported. Surface manta trawls were conducted to investigate the presence of microbeads in the southern coastal waters of Hong Kong. Considering only the size fraction of 0.3 to 1 mm, 60% of samples were found to contain microbeads. Microbeads accounted for 3.6% of the total microplastics collected and microbead abundance ranged from 0 to 380,129 pcs/km^2. The shapes, sizes, colours, and composition of microbeads found in our samples were similar to those from tested facial scrubs, suggesting that pelagic microbeads collected in this study very likely originated from the cosmetic products available locally. Microbeads represent a non-negligible part of the microplastics found in surface coastal waters.

1. Introduction

The increasing presence of plastic litter in the ocean is a growing concern of the public. Approximately 5.25 trillion plastic particles weighing 268,940 t are believed to have reached the ocean between 2007 and 2013 (Eriksen et al., 2014). Plastic pieces bigger than 5 mm are identified as macroplastic and pieces equal or smaller than 5 mm are identified as microplastic by the scientific community (Arthur et al., 2009). Microplastic particles have been found in several marine environments such as gyres, coastal surface waters, the deep sea, and beaches, and their size restricts their recovery during cleanup efforts (Lee et al., 2015; Lusher et al., 2014; Moore et al., 2001; Van Cauwenberghe et al., 2013). In the marine environment, microplastic originates from either the degradation of macroplastic pieces, which then are referred to as secondary microplastics, or direct release in their original size, which then are referred to as primary microplastics (Barnes et al., 2009).

Primary microplastics are manufactured by the industry in differing sizes depending on their usage. For example, microbeads are primary microplastics smaller than 1 mm, mainly used in personal care and cosmetic products (Schneiderman, 2014). Several studies have investigated the variety of physical characteristics (i.e. shape, colour) and composition of microbeads from personal care or cosmetics products (Cheung and Fok, 2017; Fendall and Sewell, 2009; Napper et al., 2015; Schneiderman, 2015). They observed that microbeads are principally blue, white or transparent with spherical shape and mainly polyethylene (PE) but some have polypropylene (PP) or polystyrene (PS) compositions (Zitko and Hanlon, 1991; Fendall and Sewell, 2009; Napper et al., 2015). Microbeads from personal care products sold in Hong Kong are principally a combination of colourless particles in granular shape and blue or colourless spherical pieces, mostly composed of low density polyethylene (LDPE; Cheung and Fok, 2017). Effluent outfall is considered the major source contributing to microbead pollution (Leslie, 2015; Magnusson and Norén, 2014; Murphy et al., 2016). As the substitutes of natural scrubbers in personal care and cosmetics products, plastic microbeads are designed to be ditched down the drain (Rochman et al., 2015; Schneiderman, 2014). Murphy et al. (2016) estimated that microbeads are effectively but not totally captured in the grease of wastewater treatment, leading to a non-negligible release into the aquatic environment. It has been suggested that between 80 and 98% of microbeads are retained by wastewater treatment, depending on the technology of the treatment plant (Duis and Coors, 2016; Murphy et al., 2016). Yet it was estimated that over 94,000 microbeads could wash down the drain in a single use and in each cubic meter of treated sewage discharge up to 7000 microbeads could pass through wastewater treatment screens and directly enter the sea (Napper et al., 2015; Rochman et al., 2015). Only a few studies have investigated the presence of microbeads in the ocean as both their size and their identification are difficult in the natural environment (Cheung and Fok, 2016; Isobe, 2016). Microbeads, which have a diameter around 100–200 μm (Fendall and Sewell, 2009; Napper et al., 2015), are not collected by regular surface trawling as the mesh net is typically 335 μm. In addition, the differentiation between non-spherical microbeads and secondary microplastics in samples is problematic. With

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these limitations, the identification of microbeads in previous studies are clearly underestimations; yet they are the best estimates available to evaluate the role of cosmetics and personal care products on microplastic pollution in coastal waters (Eriksen et al., 2013; Isobe, 2016).

Even though recent experiments have demonstrated the role of microbeads as a transport vector for chemicals (Napper et al., 2015), their threat to the marine environment is still debated (Koelmans et al., 2017; Rist et al., 2018). However, the source of microbeads, in comparison to secondary microplastics, is unique and therefore, any changes in personal care and cosmetics regulations will directly impact the presence of microbeads in the marine environment. Over the last five years, several countries such as the UK, Canada, and New Zealand, several states in the USA, and private sector industries have started to ban or stop the usage of microbeads in personal care products, limiting their input into the ocean (Rochman et al., 2015). Bans can be perceived as extreme but several natural replacement solutions for microbeads are available. Thus the cosmetics companies, can easily stop the contribution of microbeads to the plastic pollution observed in the ocean.

Here, we aim to quantify the microbeads present in Hong Kong coastal waters and evaluate their relative importance within the microplastic fraction. Using 147 samples from the southern region of Hong Kong, we investigated the spatial and temporal variability of the presence of microbeads.

2. Materials & methods

2.1. Sample collection

Hong Kong is surrounded by the South China Sea and situated at the estuary of the Pearl River. Seven locations around the Hong Kong territories were chosen as sampling stations, namely Aberdeen (n = 37), Chi Ma Wan (n = 27), Discovery Bay (n = 1), Pak Kok (n = 60), Po Toi (n = 13), South Lamma (n = 1), and Tung O (n = 8) (Fig. 1). From February 2016 to April 2017, opportunistic surface water trawls were conducted at each site and a total of 147 samples were gathered throughout the year. A 15-minute surface manta trawl, using a sampling net with opening of 0.5 × 1 m and a mesh size of 335 μm, was performed at a constant speed of 2 knots to collect samples. Samples were first stored in a glass bottle, transported to the laboratory at the University of Hong Kong, and kept inside the refrigerator until they were processed. Abundance of microbeads is presented by surface area estimated as follow:

$$\text{Area (km}^2) = \text{speed of vessel (ms}^{-1}) \times \text{duration of the trawl (s)} \times \text{width of the net (m)}/1{,}000{,}000$$

2.2. Sample processing

Each sample was separated into two size fractions by sieving through a 5 mm and 0.3 mm stainless-steel mesh sieve. All materials remaining on the sieves were transferred to clean beakers and dried completely in an oven at 50 °C for 24 h. The smaller size fraction samples (0.3–5 mm) underwent wet peroxidation using 30% hydrogen peroxide and 0.05 M aqueous iron (II) sulphate solution at 70 °C to oxidize organic matters (Masura et al., 2015). If organic matter was still visible, samples were further subjected to alkaline digestion with 10% potassium hydroxide solution (Foekema et al., 2013). Sodium chloride was later added to the samples to increase the aqueous density and samples were settled in filter funnels overnight for density separation. Only the floating plastic debris were collected and screened through a 0.3 mm mesh sieve (Masura et al., 2015). Samples were again thoroughly dried in an oven at 50 °C for 24 h and separated into two size fractions of 1 to 5 mm and 0.3 to 1 mm by sieving through stainless-steel sieves with mesh sizes of 1 mm and 0.3 mm. Plastic samples smaller than 1 mm were preserved in glass petri dishes for visual sorting of microbeads under a stereomicroscope (40 ×; stemi 305; Carl Zeiss Microscopy GmbH). Efforts to limit sample contamination included ensuring that all materials used during sample processing were thoroughly cleaned before usage and covered after each step. Microplastic particles with spherical shapes within the 0.3–1 mm size fraction were considered microbeads and as such were sorted and counted. Due to the impossibility to distinguish between granular microbeads and secondary microplastic produced by the degradation of bigger plastic pieces combined with the limitation of the mesh size of the net used to collect samples, microbead abundance presented below is an

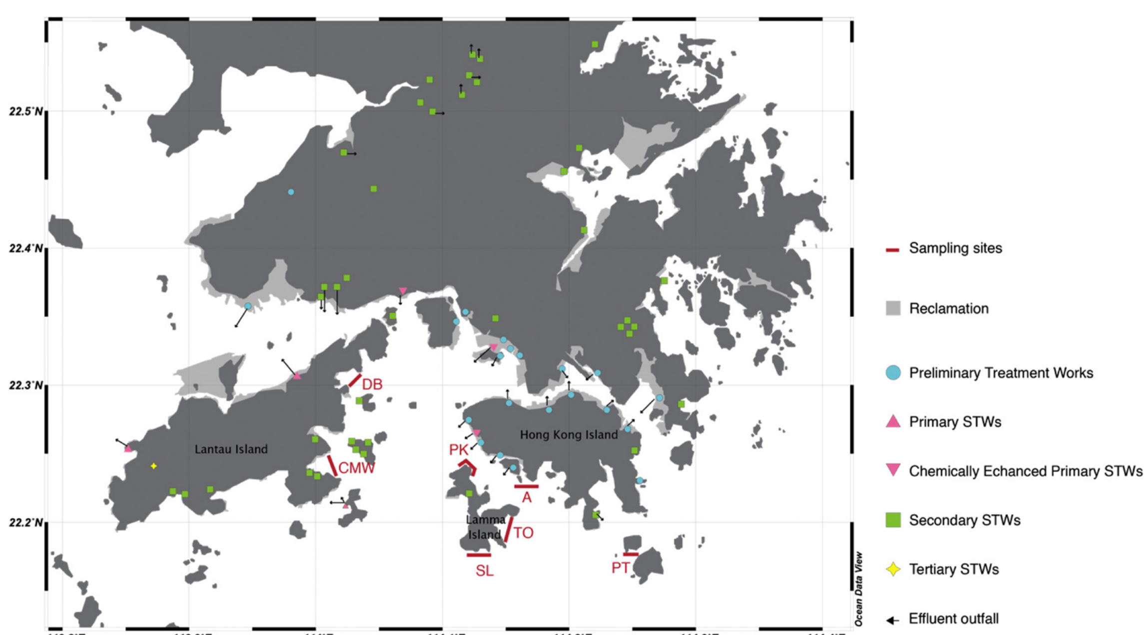

Fig. 1. Map of Hong Kong with the seven sampling locations: Aberdeen (A), Chi Ma Wan (CMW), Discovery Bay (DB), Pak Kok (PK), Po Toi (PT), South Lamma (SL), and Tung O (TO). Sewage treatment works are located with information about their effluent outfall direction and the type of treatment (Drainage Service Department, 2015). Dark grey represents the natural coastline whereas the light grey represents coastline after land reclamation.