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Microplastic pollution in the marine waters and sediments of Hong Kong

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ABSTRACT

The presence of plastic waste with a diameter of less than 5 mm ("microplastics") in marine environments has prompted increasing concern in recent years, both locally and globally. We conducted seasonal surveys of microplastic pollution in the surface waters and sediments from Deep Bay, Tolo Harbor, Tsing Yi, and Victoria Harbor in Hong Kong between June 2015 and March 2016. The average concentrations of microplastics in local coastal waters and sediments respectively ranged from 51 to 27,909 particles per 100 m^3 and 49 to 279 particles per kilogram. Microplastics of different shapes (mainly fragments, lines, fibers, and pellets) were identified as polypropylene, low-density polyethylene, high-density polyethylene, a blend of polypropylene and ethylene propylene, and styrene acrylonitrile by means of Attenuated Total Reflectance - Fourier Transform Infrared Spectroscopy. This is the first comprehensive study to assess the spatial and temporal variations of microplastic pollution in Hong Kong coastal regions.

1. Introduction

The presence of small plastic debris in the marine environment is gaining increasing attention from researchers, regulatory authorities, and the public both locally and globally. The term "microplastic" is commonly used to define plastic debris with a diameter of less than 5 mm. However, some studies have been using the terminology "microplastic" in a much broader scope by, for example, including particles as small as 1 mm or as large as 10 mm (Browne et al., 2010; Carson et al., 2011; Van Cauwenberghe et al., 2013a; Qiu et al., 2016). Although the ecological and public health effects of microplastics have yet to be fully elucidated, microplastics in the oceans have been assumed to be potentially toxic and can adversely affect organisms throughout the food web. So far studies suggest microplastic toxicity might originate within two processes. Firstly, because microplastics have large surface area–to–volume ratio, marine pollutants such as trace metals and persistent organic pollutants might easily be adsorbed by the marine plastic debris which accordingly acts as a transport medium for toxic pollutants (Frias et al., 2010; Andrady, 2011; Cole et al., 2011; European Commission, 2011; do Ivar and Costa, 2014). Secondly, the toxicity of microplastics might also originate from the inherent toxicity of monomers and different types of additives (e.g., bisphenol A, phthalates, flame retardants) mixed to monomers during the manufacturing process to improve physical and chemical properties of plastics (European Commission, 2011; do Ivar and Costa, 2014). Ingestion of microplastics by marine organisms such as planktons, crustaceans, fish, filter feeders such as mussels, and seabirds has been systematically observed around the world (Blight and Burger, 1997; Erikson and Burton, 2003; Betts, 2008; Teuten et al., 2009; Thompson et al., 2009; Boerger et al., 2010; von Moos et al., 2012; Tanaka et al., 2013; do Ivar and Costa, 2014; Avio et al., 2015). Microplastics and their associated toxic chemicals might lead to more critical negative effects on ecosystems and human health than those of large plastic debris since they might bioaccumulate and biomagnify along the food web (European Commission, 2011; Farrell and Nelson, 2013; Wright et al., 2013; do Ivar and Costa, 2014).

Several assumptions tend to be made about microplastics. First, because of their wide presence in the world's oceans and second because they are a sink for various environmental toxic chemicals and can cause adverse ecological effects. However, these are just hypotheses that have yet to be further investigated. Some researchers have already conducted field studies of microplastic pollution in the marine environments of their countries. It is strongly believed that Hong Kong is also subject to marine microplastic pollution. There were few studies investigating the occurrence of plastic debris and associated toxicants in beaches in Hong Kong. In 2011, beached plastics pellets collected from Sam Pak Wan, Hong Kong were found to contain high concentrations of polychlorinated biphenyl (PCBs) (757 ng/g-pellets) (Takada, 2011). Cheung et al. (2016) reported that the average amount of microplastics collected at 25 local beaches during wet season (June to August 2014) and dry season (January to March 2015) were 5595 ± 3950 items/m^2 and 889 ± 350 items/m^2 respectively. However, the severity of microplastic pollution in the local marine environment is basically unknown. This study aims to assess the presence and distribution of microplastics in the marine waters and sediments of Hong Kong. A comparison of the spatial and temporal patterns of microplastics with the

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findings from other countries or territories will help to fill the knowledge gap and determine whether microplastic pollution is a significant environmental problem in Hong Kong that requires our immediate action.

2. Materials and methods

2.1. Sampling locations and sampling periods

The marine environment of Deep Bay (two sampling transects of inner and outer Deep Bay), Tolo Harbor (two sampling transects of Ma On Shan New Town and Tai Po of inner Tolo Harbor), Tsing Yi (two sampling transects east and north of Tsing Yi Island), and Victoria Harbor (three sampling transects at Kowloon East, Kowloon West, and northeast of Hong Kong Island) were selected as the sampling sites from which surface water (along transects) and sediment samples were collected. These sites are located in landlocked areas that receive urban runoff from densely populated urban regions that contain residential, industrial, and commercial building blocks. Fig. 1 shows the nine sampling sites and their respective transects on a map of Hong Kong. To study the temporal variation of microplastics in each sampling site during both dry and wet seasons, sampling was conducted during June and July 2015 (wet season), November 2015 (beginning of the dry season), and March 2016 (end of the dry season).

2.2. Sample collection

Water samples were collected from each transect by towing a plankton net (153 μm) for 30 min at a speed of 3 to 5 knots. A flowmeter was used to calculate the amount of water passing through the net. The particulates inside the net tube and those retained in the net were washed into a glass container for later laboratory analysis (modified from Zhao et al., 2014). Before or after towing, surface sediment samples (around 3 kg) were collected by using an Ekman dredge. The samples were freeze-dried before laboratory analysis (modified from Vianello et al., 2013). Data from different transects were averaged to represent the level of microplastic pollution in the surface waters and sediments from different coastal regions: Deep Bay (transects 1 & 2), Tsing Yi (transects 3 & 4), Victoria Harbor (transects 5, 6 & 7), and Tolo Harbor (transects 8 & 9).

2.3. Extraction of microplastics

Large debris in the water samples were first screened and discarded with the help of a 32-μm steel-wire sieve, and the particulates were then resuspended in milli-Q water. If the suspension was too turbid to be filtered directly, saturated sodium chloride solution was added. Microplastics of lower density than the solution, if any, would float up to the surface. The samples were then filtered over a 0.7-μm glass

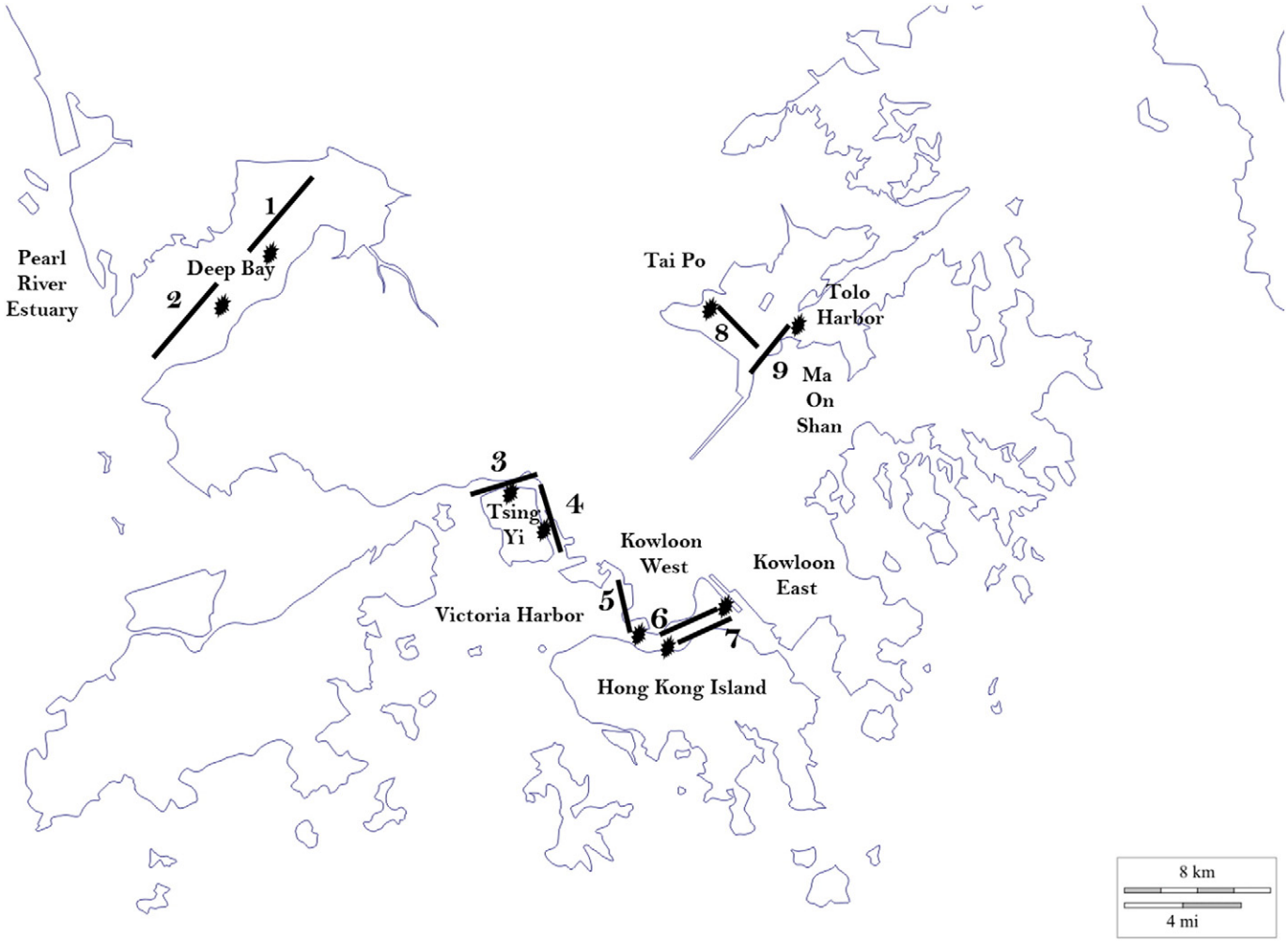

Fig. 1. Sampling transects for microplastic survey on Hong Kong coastal regions. Nine sites (1–9). Trawling transect ——. Sediment Station ✸. Water samples were collected from each transect by towing a plankton net (153 μm) for 30 min at a speed of 3 to 5 knots. Before or after towing, surface sediment samples (around 3 kg) were collected by using an Ekman dredge. Data from different transects were averaged to represent the level of microplastic pollution in the surface waters and sediments from different coastal regions: Deep Bay (transects 1 & 2), Tsing Yi (transects 3 & 4), Victoria Harbor (transects 5, 6 & 7), and Tolo Harbor (transects 8 & 9).

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