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Exploration of microplastics from personal care and cosmetic products and its estimated emissions to marine environment: An evidence from Malaysia

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ABSTRACT

This study aims understand microplastics from personal care and cosmetic products in Malaysia via quantification and characterization of microplastics together with emission estimation to marine environment. A total of 214 respondents from all over Malaysia were surveyed with identification of top ten personal care and cosmetic products usage. Particles found in facial cleaner/scrub and toothpaste were colored and colorless with majority of granular shapes. Particles in toothpaste were found between 3 and 145 μm while particles in facial cleaner/scrub were found to be between 10 and 178 μm, stipulating the presence of microplastics. Plastic polymers (LDPE and polypropylene) were found in all facial cleaner/scrub samples while only plastic polymers (LDPE) were present in toothpaste sample G. A total of 0.199 trillion microplastics are expected to be released annually to marine environment in Malaysia. Personal care and cosmetic products are seen as one of the microplastics sources for Malaysia and worldwide.

1. Introduction

Generally, the marine environment receives large plastic items from land-based sources and rubbish dumped from ships at sea. Unfortunately, the marine environment is also contaminated with microplastics (smaller than 5 mm), generated from primary and secondary sources which is a looming threat to the preservation of the marine environment (Cheung and Fok, 2016; Cole et al., 2011; Ivar Do Sul and Costa, 2014). In fact, primary sources of microplastics are direct input from personal care and cosmetic products as well as plastic pellets in other plastic production. On the other hand, secondary sources include further breakdown of large plastic debris. Specifically, the large plastic debris undergo some form of degradation and fragmentation by UV solar radiation to form smaller plastic particles in marine environment (Ivar Do Sul and Costa, 2014).

Amount of microplastics has been a subject of increasing environmental concern although ecotoxicological effects of these microplastics are still unclear (Cheung and Fok, 2017). Among the studied microplastics, less focus has been placed on microplastics particles present as ingredients in personal care and cosmetic products. In general, microbeads is a term used by industries to define microplastics in personal care and cosmetics products (Isobe, 2016). However, not all the particles found in personal care and cosmetics products are associated with microplastics. Synthetic polymers associated with microplastics are polyethylene (PE), polyester (PES), polyvinyl chloride (PVC) and high density polyethylene (HDPE) (Li et al., 2016). Undoubtedly, microplastics has been identified to be a source of plastic pollution in marine environment (Isobe, 2016). However to date, only a few studies have been conducted on microplastics from cosmetics and personal care products and cosmetics emission to marine environment (Chang, 2015; Cheung and Fok, 2017; Isobe, 2016). Wastewater treatment plants (WWTP) has been identified as a one of the potential contributors for microplastics cosmetics and personal care products and cosmetics emission into the marine environment. As a matter of fact, microplastics in cosmetics and personal care and cosmetics products from consumer usage are washed directly into household drains and transported to WWTP (Murphy et al., 2016). In WWTPs, these microplastics will pass through various treatment stages where a substantial amount of microplastics will be extracted out by WWTPs. However, there are number of studies which have reported occurrence of

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microplastics detected in treated WWTP effluents where the retention of these microplastics depends on size and types (Gies et al., 2018; Mourgkogiannis et al., 2018; Neale and Leusch, 2017; Ziajahromi et al., 2017). According to a previous study, Napper et al. (2015) have estimated that an average of 49,547 microplastics particles in a single use could be emitted into the environment per use involving UK population, while a recent analysis stated that an average of 209.7 trillion microplastics discharged annually into the marine environment in Mainland China (Cheung and Fok, 2017). Similarly, Carr et al. (2016) and Peters and Bratton (2016) have also found substantial amount of multi colored microplastics of various sizes and shapes from the surface waters which received treated WWTP effluents. Although microplastics are small in terms of weight and abundance, the continuous loadings of microplastics from WWTP effluent will exhibit detrimental environmental and aquatic life effects in the future.

On top of that, there has been limited studies on microplastics or microplastics pollution in Malaysia. At present, most of the studies have addressed only on the quantification of plastic waste in beach sand by Fauziah et al. (2015), intertidal area zone by Ismail et al. (2009), mangrove forest by Barasarathi et al. (2011), core sediment by Matsuguma et al. (2017) and microplastics ingestion by *Scapharca* in wetland by Shuaib Ibrahim et al. (2016). Clearly, these studies have specifically addressed the absence on studies regarding microplastics pollution in Malaysia. Since Malaysia's total trade volume for personal care and cosmetics products was about US$2.24 billion in 2015, this sector has continuously exhibited the greatest demand by consumers. With 70% of Malaysians being urban dwellers, both sexes have increased their demands for quality personal care and cosmetics products which may directly introduce large number of microplastics into wastewater and henceforth, to marine environment (United Nations Environment Programme, 2015). Meanwhile, the Southeast Asian Nations (ASEAN) Cosmetic Association has issued a ban on the use of plastic microplastics in personal care products. Additionally, personal care and cosmetic companies in Asia also supported this move by reciprocating the initiative. However, there is still zero quantitative data and regulation concerning microplastics emission into the marine environment in Malaysia and Southeast Asia countries.

Thus, this study aims to explore and comprehend the characteristics and views of Malaysian on microplastics in personal care products. Next, this study aims to identify the top ten personal care products and cosmetics as well as its usage rate by Malaysians through a questionnaire survey. Besides, particles characterization and composition of microplastics found in top ten personal care products and cosmetics used in Malaysia was also conducted. Lastly, total emission of microplastics from top ten personal care and cosmetics products discharged from WWTP to marine environment was also estimated. These findings acts as a pioneer on identification and quantitative findings of microplastics pollution from personal care and cosmetics products with its emission into the marine environment in Malaysia. Similarly, these findings will also give an indicator on global occurrence and an increase of microplastics pollution which is currently limited in Southeast Asia.

2. Material and methods

2.1. Questionnaire survey

A questionnaire survey was developed to obtain the top ten personal care products and cosmetics used together with customer usage data in Malaysia. Specifically, the questionnaire consists of five questions encompassing sociodemographic data, the most used, frequency of usage, environmental impacts, and awareness of plastics and microplastics in personal care products. Initially, the questionnaire was pretested and the Cronbach's alpha value of 0.73 was obtained to ensure consistency of the questionnaire. Then, the questionnaire survey was distributed using online Google Form via email and social media platforms including Facebook, Twitter and Whatsapp. The questionnaire survey results were used to model for a larger Malaysia population in estimation of microplastics emission into the wastewater influent and the marine environment.

2.2. Selection of top ten personal care products and cosmetics and sample preparation

A total of ten personal care products and cosmetics were selected based on questionnaire survey results provided by Malaysians in their daily life usage. From the list, the top five facial cleaner/scrub and toothpaste products were identified. Since specific brand of product names were not of particular relevance, the products were labelled A to J. Samples A to E are facial cleaner/scrub while samples F to J are toothpaste products.

Next, the sample preparation of each product which involved extraction and enumeration process was carried out based on the modified method described by Cheung and Fok (2017). In particular, a total of 2 g was weighed and dissolved in a glass conical flask containing 150 mL boiling water. Then, the mixture was stirred using a glass rod until fully dissolved and filtered using *0.45* μm Whatman filter paper by vacuum filtration. After the filtration process, a 50 mL of deionised water was added to further dissolve the solution and purify the particles. Once the particles have undergone purification, the residue which contained microplastics was oven dried at 50 °C to constant weight. As soon as the microplastics became dry, the mass of the particles were weighed using analytical balance and stored in glass vials for further analysis. In order to obtain representative results, this particular step was repeated ten times.

2.2.1. Identification and visualisation of particles in personal care products

For identification and visualisation of particles in personal care products, triplicate samples from the extracted of particles from ten personal care products and cosmetics were used. Furthermore, the identification of particles from each sample preparation step was further analyzed using the Nikon Eclipse E200LED MV RS microscope coupled with BestScope International Limited camera and KSJShow software to identify the size, shape and color of these polymers. The images were also analyzed using an open-source particle analysis software named ImageJ 1.51 (http://imagej.nih.gov). Essentially besides using microscope coupled with camera and software, Image J also enables measurements of particles to be captured in image and is commonly applied in microplastics studies (Maes et al., 2017; Isobe et al., 2017). Next, the composition of polymers was identified using Thermo Scientific Nicolet 6700 FTIR Spectrometer. Point and shoot analysis with manually operated FTIR microscope using a single element MCT-A liquid-nitrogen-cooled detector for speed was applied. In addition, spectra of the unknown particles in each sample were obtained and compared from 500 to 4000 cm^{-1} to a spectral database of synthetic polymers (Thermo Scientific OMNIC Spectra and Essential FTIR ® Spectroscopy Toolbox softwares).

2.3. Estimation of microplastics emissions in Malaysia

In this section, the estimation of microplastics emission into the marine environment is assumed in two ways, namely through direct microplastics emissions from personal care products and cosmetics in areas without sewage treatment (DME) and microplastics escape (ME) from WWTP. Specifically, direct microplastics emissions from personal care products and cosmetics in areas without sewage treatment was calculated using Eq. (1) which is a method modified from the estimation calculation applied by Cheung and Fok (2017). With relation to this method of estimation, Table 3 presents the values used in the direct microplastics emissions from personal care products and cosmetics in areas without sewage treatment. On the other hand, microplastics escape from WWTP (ME) was calculated using Eq. (2). To the authors knowledge, there is still no any study available related to microplastics