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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 escape from WWTPs in Malaysia, thus the value of estimate escape rate (R_{escape}) was obtained from Cheung and Fok (2017). As a matter of fact, this value was a median value of previous studies which reported the microplastics release from WWTPs. In the context of treated sewage volume, the treatment and release of 2.97 billion m^3 of domestic sewage from WWTP documented by Engku Azman Tuan Mat and Jamil Shaari (2013) was incorporated with the assumption that the density of sewage is equal to 1000 kg m^{-3}. As shown in Eq. (3), the total microplastics emission into the marine environment is a summation of DME and ME.

$$DME = TP \times P_{20-44} \times R_c \times P_{mb} \times N_{use} \times W \times D_{mb} \times R_{untreated} \quad (1)$$

$$ME = R_{escape} \times V \quad (2)$$

$$\text{Total microplastics emission into the marine environment} = DME + ME \quad (3)$$

Where:TP is total population, P_{20-44} is percentage of population aged between 20 and 44 years old (population age from 20 to 44 years old was selected as this is the highest personal care and cosmetics products users in Malaysia), R_c is product usage rate, P_{mb} is percentage of facial scrubs containing plastic microplastics, N_{use} is no. of uses per year, W is weight of product used each time, D_{mb} is density of microplastics in facial scrubs, $R_{untreated}$ is percentage of untreated sewage, R_{escape} is product of the estimated escape rate, V is treated sewage volume (V).

Therefore, using the estimation calculations, the emission of microplastics into the marine environment in Malaysia was calculated. Volume of microplastics emission from each state in Malaysia into the marine environment is assumed to be proportional to the population living in Malaysia.

3. Results and discussion

Table 1 presents the information obtained from questionnaire survey. A total of 214 respondents from all over Malaysia have participated in the questionnaire survey. Based on the survey conducted, the respondents were identified to be of age 18–59 years old. Majority of the respondents were between 21 and 29 years old which was influenced by users of those methods of dissemination (email, Facebook, etc.) and internet access. Besides, the most used personal care products and cosmetics (in terms of amount) identified were toothpaste and face cleaner/scrub with 73% of the respondents using these products three times a day. Conversely, 62.6% of the respondents acknowledged very and extremely important of taking into consideration the environmental impacts resulted from microplastics in personal care products. In fact, it was discovered that 95.8% of the respondents trusted that the personal care products and cosmetics used are environmental-friendly although 50% of the respondents were aware that plastics were a major component in certain personal care products. Lastly, almost 50% of the respondents still use personal care products and cosmetics that contain microplastics despite knowing about the harmful effects of microplastics.

In this investigation, 14 brands of toothpastes and 25 brands of facial cleansers/scrubs were identified by the respondents. Then, it was followed by the identification of the top five facial cleaner/scrub and toothpaste products. Characterization of particles found in all the investigated facial cleaner/scrub (A-E) and tooth paste products (F-J) are presented in Table 2. For both products, particles were revealed to be colored (green, blue, light brown) and colorless (Supplementary 1). Besides, almost all the particles in these products possessed granular and irregular shapes (Fig. 1). According to Cheung and Fok (2016) and Fendall and Sewell (2009), similar granular and irregular shapes of particles were also present in personal care products.

Particles in facial cleaner/scrub and toothpaste products were shown to have a wide size range including < 1 mm. The particle size for facial cleaner/scrub ranged from 10 to 178 μm while the particle size

Table 1
Information of top ten personal care and cosmetics products used with customer usage data in Malaysia (n = 214).

Variable	N (%)
Age (years)	
18–20	16 (7.5)
21–29	121 (56.5)
30–39	54 (25.2)
40–49	12 (5.6)
50–59	11 (5.2)
The most used personal care product (in terms of amount) so far	
Toothpaste	137 (64)
Face cleaner/scrub	65 (30.3)
Body scrub	10 (4.7)
Moisturizer	2 (0.9)
Frequency usage	
None	2 (0.9)
Only once	12 (5.6)
Twice	112 (52.6)
3 times	73 (34.3)
> 3 times	14 (6.6)
Environmental impacts resulted from buying personal care and cosmetics products containing microplastics	
Extremely important	55 (25.7)
Very important	79 (36.9)
Moderately important	51 (23.8)
Slightly important	27 (12.6)
Not at all important	2 (0.9)
Trust that the personal care products I use is safe to environment	
Yes	205 (95.8)
No	9 (4.2)
Aware that there are plastics in certain personal care products?	
Yes	107 (50)
No	107 (50)
Do you know what microplastics are?	
Yes	108 (50.5)
No	106 (49.5)

for toothpaste ranged from 3 to 145 μm. However, it should be noted that the current findings (particle size) were lower than the particle sizes reported by Cheung and Fok (2017) between 24 and 800 μm, Fendall and Sewell (2009) between 4.1 and 1240 μm and Napper et al. (2015) with a mean diameter of 163.82 μm. This outcome can be related to methodology techniques employed in microplastics identification. Besides FTIR spectroscopy, dynamic light scattering measurement in microscope coupled with camera and software has been utilized for both small (< 20 μm) and large particles (> 20 μm) as shown in Supplementary 2. Similarly, micro level image analysis using ImageJ functions also has been utilized to explore and determine small particle size (Hernandez et al., 2017; Rana, 2015). According to Song et al. (2015), combination of different microplastics identification methodology techniques namely microscopic, spectroscopic, naked eye and instrumental will help to recognise smaller microplastics. Besides, the extracted microplastics particles from any media is also influenced by filter size used in extraction step. As this study used 0.45 μm Whatman filter paper in extraction process which was smaller than filter sizes used by Cheung and Fok (2017), Whatman Grade 1 filter (pore size: 11 μm), Fendall and Sewell (2009), an 8 lm nitrocellulose membrane filter and Napper et al. (2015), Whatman N°4 filter paper with pore size between 20 and 25 μm. Thus, smaller filter size in extraction step has enabled smaller microplastics to be extracted and identified.

Since particle sizes in all facial cleaner/scrub and tooth paste products (A–J) have indicated the possibility of microplastics (< 5 mm) being present, further identification of these microplastics using FTIR will facilitate in determining its composition. Table 2 shows the summarized information of particle composition of facial cleaner/scrub and tooth paste products (A–J). Facial cleaner/scrub (A–E) products were

Table 2
Characteristics of particles found in top ten personal care and cosmetics products.

Type of sample	Sample	Color	Shape	Size (μm)	Mean density ± SD (particles/g)	Mean particle weight ± SD in the product (%)	Composition
Facial cleaner/ scrub	A	Green mainly Light Brown	Granular	G: 23–85	11,776 ± 138	2.5 ± 0.13	• Low-density polyethylene (LDPE) • Triacontane
	B	Colorless	Spherical Granular (mainly)	C: 10–165	36,636 ± 285	5.0 ± 0.22	• Low-density polyethylene (LDPE) • Triacontane
	C	Colorless	Granular	C: 15–159	22,585 ± 1236	1.50 ± 0.13	• Low-density polyethylene (LDPE) • Triacontane
	D	Green Colorless	Granular	C: 15–142	21,410 ± 2835	1.50 ± 0.47	• Low-density polyethylene (LDPE) • Triacontane
	E	Colorless	Granular	C: 12–178	27,688 ± 723	2.03 ± 1.14	• Polypropylene • Cellophane
Toothpaste products	F	Colorless	Granular	C: 3–123	43,885 ± 2186	20.43 ± 29.34	• 2-Fluoroethanol • Calcium phosphate type IV tribasic
	G	Blue Colorless	Granular	B: 13–110	48,992 ± 1396	7.24 ± 0.64	• Low-density polyethylene (LDPE) • 2-Fluoroethanol • Calcium phosphate type IV tribasic
	H	Colorless	Granular	C: 5–145	52,342 ± 2954	8.65 ± 2.13	• 2-Fluoroethanol • Ethanolamine
	I	Colorless	Granular	C: 5–134	32,450 ± 2331	45.28 ± 3.21	• Calcium carbonate • Methylenecyclobutane
	J	Colorless	Granular	C: 4–139	19,543 ± 873	13.84 ± 1.23	• 2-Fluoroethanol • Calcium phosphate type IV tribasic

shown to contain LDPE and polypropylene which are the most common type of plastic polymers found in microplastics. Also, microplastics which possess a size of up to 500 μm in diameter can be found in personal care products and cosmetics such as facial cleaner/scrub and act as substitutes for natural exfoliating materials and scrubbing agent (Cheung and Fok, 2016; EPA, 2016). Moreover, similar plastic composition of LDPE in microplastics have been detected in facial scrubs by Cheung and Fok (2017), Napper et al. (2015), Anderson et al. (2016), Cheung and Fok (2016) and Chang (2015). However, plastic polymers were absent in toothpaste except for sample G which contains LDPE. Microplastics were added into toothpaste to enhance aesthetics and aid in cleaning and functions as a smoothening agent. Additionally, different colors were included to brighten up toothpastes in order for them to be visually appealing (iNews, 2016). Likewise, other compounds such as cellophane, 2-Fluoroethanol, calcium phosphate type IV tribasic, diethanolamine, calcium carbonate and methylenecyclobutane are among the most commonly used agents in toothpaste products.

Moreover, Table 3 shows the estimated emission of microplastics from personal care products and cosmetics into the marine environment in Malaysia. It is estimated that a total of 0.199 trillion microplastics are emitted into the environment annually in Malaysia through face cleaner/scrub and toothpaste products. Besides, 95% of the total microplastics emissions were also discovered to be emitted into the environment through direct emission of untreated sewage. On the other hand, the remaining 5% of the total microplastics emissions were emitted into the environment via treated effluent through incomplete

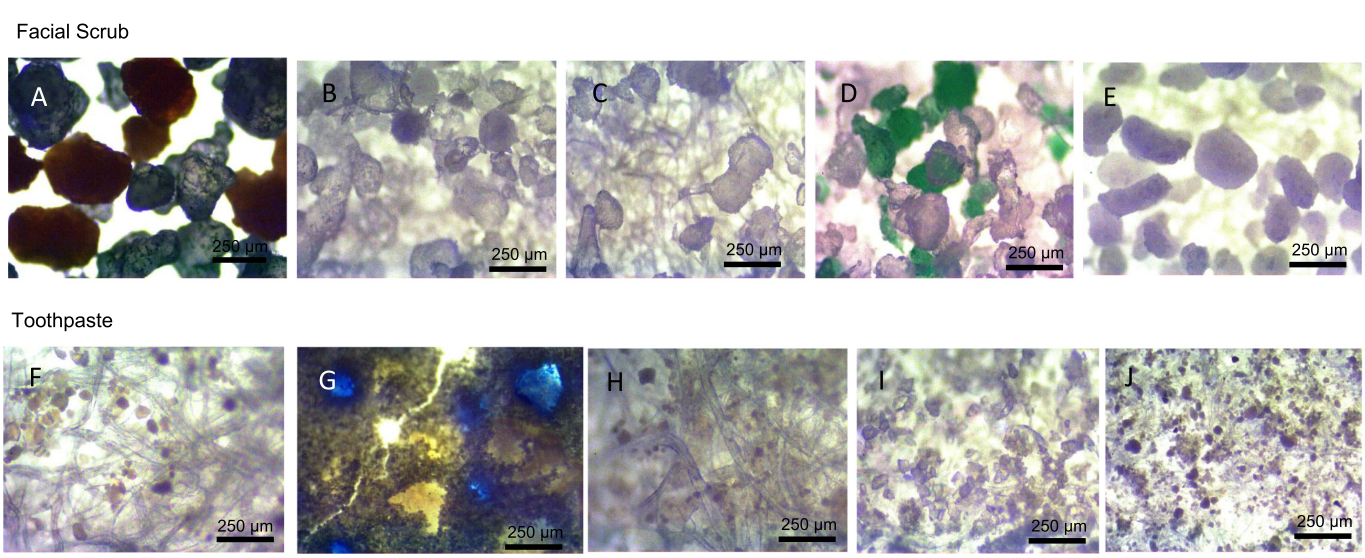

Fig. 1. Photos of the microplastics particles in facial scrubs and tooth paste products (A-J).

Table 3
Values used in the direct microbeads emissions from personal care and cosmetics products in areas without sewage treatment.

	Direct emission			Microbeads escape from WWTP			
Terms	Description	Values	Source	Terms	Description	Values	Source
TP	Total population	31.7 million	Department of Statistics Malaysia (2016)	R_{escape}	Estimate escape rate	3.45 particles/L	Cheung and Fok (2017)
$P_{20–44}$	% population aged between 20 and 44 years	40%		V	Treated sewage volume	2.97 billion m^3	Engku Azman Tuan Mat and Jamil Shaari (2013)
Rc	Personal product usage rate	52.60%	From questionnaire				
P_{mb}	% of personal care product that contain plastic microbeads	44%	Beat the Microbead (www.beatthemicobeads.org)				
N_{use}	Number of uses per year	52 times	From questionnaire				
W	Weight of product used each time	1.1 g	Park et al. (2015)				
Dmb	Density of microbeads in personal care products	28,181	This study				
$R_{untreated}$	% untreated sewage	4%	Japan Sanitation Consortium (2011)				
Microbeads emission in number	0.189 trillion			0.01 trillion			
Total microbeads emission in number	0.199 trillion						

removal of microplastics in WWTP. Based on the latest study, the estimated emission of microplastics in Malaysia is lower than the estimated value (38.2 trillion microplastics) in Mainland China (Cheung & Fok, 2017). This can be due difference in the number of populations between Malaysia (32.0 million) compared with China (1.42 billion). Despite the crucially of this issue which involves density unit presented by Napper et al. (2015), an estimated amount of between 4594 and 94,500 microplastics per gram could possibly be released into the environment per use. Even though studies with regards to microplastics emission from personal care products and cosmetics are limited, this current study and previous related studies have highlighted the fact that continuous usage of personal care products and cosmetics daily can release huge amount of microplastics to environment.

Current findings indicated that emissions of microplastics from personal care products and cosmetics would undeniably contribute to microplastics contamination in the marine environment. Inevitably, once personal care products and cosmetics are used, microplastics would subsequently travel from wastewater systems and escape into the marine environment. Eventually, microplastics would pervade the bigger mesh size of wastewater plants screen and enter into the marine environment (Fendall and Sewell, 2009). In Malaysia, majority of wastewater treatment types are preliminary (rags, rubbish, grit, oil, grease removals), primary (settleable and floatable materials removal) and secondary treatment (biological treatment to remove organic and suspended solids). Thus, microplastics removal in wastewater can be conducted via total suspended solids removal which removal of suspended solids were conducted in primary, secondary and tertiary WWTPs in Malaysia (Engku Azman Tuan Mat and Jamil Shaari, 2013). Due to limited information available on different types and characteristics of WWTPs in Malaysia, it was not possible to discuss on different WWTPs to retain different amount of microplastics. Thus generally in any WWTPs, a certain amount of microplastics can be removed especially through sludge setting and skimming treatment processes (Carr et al., 2016; Kalčíková et al., 2017; Murphy et al., 2016). Murphy et al. (2016) reported that microplastics including microplastics are removed through primary setting and clarification processes. Kalčíková et al. (2017) has confirmed that 52% of microplastics in wastewater are captured in the activated sludge in lab-scale wastewater treatment experiment. Thus, the combined effort of suspended solids removal at three different stages will ultimately provide assistance in capturing certain proportion of microplastics. However, the fact that smaller microplastics will be able to escape and enter into the marine environment remains unchanged. Interestingly, plastic polymers in microplastics are believed to linger until hundreds of years before reaching the state of complete degradation. In this respect, further degradation of these microplastics via chemical, physical and biological processes will most likely result in nanoplastic formation. Napper et al. (2015) also presented the notion that microplastics can function as transport vectors of waterborne pollutants and possess the potential of adsorbing a wide range of hydrophobic chemical pollutants. Moreover, hydrophobic nature of nanoplastics will allow easier access into cells, which will lead to cytotoxicity (Hernandez et al., 2017). Although knowledge gaps still exist in substantiating this issue regarding the impacts of microplastics in the marine environment, these findings have significantly stressed on the adverse effects of continuous use and emissions of personal care and cosmetics products containing microplastics which are resilient in the environment.

There are several uncertainties in the estimation of microplastics from personal care and cosmetics products have been identified and could be further improved in future study. The inclusion of microplastics density and escape rates values from local wastewater in Malaysia will be influential in significantly improving the current microplastics emission results. Moreover, accurate calculations with regards to the weight of facial cleanser/scrub used will effectively assist in the microplastics emission estimation. Since this study was conducted based on the top ten personal care and cosmetics products (facial cleaner/scrub and toothpaste), a detailed analysis on other personal care and cosmetics products (shower gel, shampoo) are also need to be considered. In addition to microplastics estimation, it is also crucial to conduct wastewater sampling and analysis to estimate different types of microplastics escape from different types of WWTPs in Malaysia. This will also contribute meaningful data in providing a comprehensive insight on microplastics emissions into the Malaysian marine environment.

4. Conclusion

In conclusion, this present work featured respondents aged between 21 and 29 years old with the majority using personal care product thrice a day. The questionnaire survey has identified the top ten five toothpaste and face cleaner/scrub by respondents. Particles found in toothpaste and face cleaner/scrub were a mixture of colored (green, blue, light brown) and colorless with granular and irregular shapes, ranged from 10 to 178 μm for facial cleaner/scrub while the particle size for toothpaste were ranged from 3 to 145 μm. Most importantly, the FTIR results indicated that all the facial cleaner/scrub (A–E) products contain LDPE and polypropylene, which are the most common types of plastic polymers found in microplastics (typically referred to as microplastics). It was highlighted that a total of 0.199 trillion microplastics were estimated to be emitted from personal care and cosmetics products into marine environment in Malaysia. There has been no permanent effective removal method to eliminate these particles once they have been emitted into the environment. Despite the countless number of successful campaigns and measures taken by manufacturers to ban these microplastics in their products, further initiatives and follow-ups are necessary to supplement this motion. Thus, current findings can act as a communication tool among scientific communities, regulatory bodies, policy initiatives and public to phase out the use of microplastics in Southeast Asia.

Declarations of interest

None.

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Supplementary data

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