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Note

Contributing to marine pollution by washing your face: Microplastics in facial cleansers

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ABSTRACT

Plastics pollution in the ocean is an area of growing concern, with research efforts focusing on both the macroplastic (>5 mm) and microplastic (<5 mm) fractions. In the 1990s it was recognized that a minor source of microplastic pollution was derived from liquid hand-cleansers that would have been rarely used by the average consumer. In 2009, however, the average consumer is likely to be using microplastic-containing products on a daily basis, as the majority of facial cleansers now contain polyethylene microplastics which are not captured by wastewater plants and will enter the oceans. Four microplastic-containing facial cleansers available in New Zealand supermarkets were used to quantify the size of the polyethylene fragments. Three-quarters of the brands had a modal size of <100 microns and could be immediately ingested by planktonic organisms at the base of the food chain. Over time the microplastics will be subject to UV-degradation and absorb hydrophobic materials such as PCBs, making them smaller and more toxic in the long-term. Marine scientists need to educate the public to the dangers of using products that pose an immediate and long-term threat to the health of the oceans and the food we eat.

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1. Introduction

Plastics are a ubiquitous part of modern life, encountered on a daily basis in the packaging of foods and drinks, in household items such as combs, toothbrushes and pens, and in shopping bags. The final destination of many large plastic items are the oceans, where they form the macroplastic debris (>5 mm, Moore, 2008) that is a dominant component of ocean pollution, threatening marine life through consumption and/or entanglement (Derraik, 2002; Moore, 2008). Recent research has described areas of the open oceans where oceanographic features have concentrated this material (e.g., the North Pacific Gyre, Moore et al., 2001; Moore, 2008; the Kuroshio Current, Yamashita and Tanimura, 2007) and areas far from human habitation are littered with macroplastics, particularly fishing debris (e.g. the Sub-Antarctic islands, Derraik, 2002; Moore, 2008).

In the last few years there has, however, been a major change in the potential for microplastic (<5 mm, Moore, 2008) pollution in the oceans, with the shift from natural to microplastic exfoliators in skin cleansers. Although first recognized as a minor source of plastic pollution in the 1990s (Zitko and Hanlon, 1991; Gregory, 1996), these microplastics were primarily present in hand-cleansers, as liquid plastic-sand soaps that might typically be used on rare occasions by the average consumer. However, because microplastics have now replaced natural exfoliating materials (e.g. pum-

ice, oatmeal, apricot or walnut husks) in facial cleansers, the average consumer now has a microplastic-containing product in their home and uses it on a daily, or at least weekly, basis. The majority of facial cleansers in New Zealand supermarkets list polyethylene as an ingredient, present in forms variously described as “micro-beads”, “microbead formula” or “micro exfoliates”.

Once used in face-washing the microplastics travel through city wastewater systems, but because of their small size are likely to escape capture by the preliminary treatment screens on wastewater plants (typically coarse, >6 mm, and fine screens, 1.5–6 mm Vesilend, 2003) and enter the oceans (Browne et al., 2007). To determine the impact of plastic from facial cleansers on the marine environment we here quantify the size of plastic contained in four brands readily available from New Zealand supermarkets. The size range of particles present suggest that facial cleansers may now be a major source of microplastics pollution in the ocean, and will have both immediate and long-term impacts on plankton and filter-feeding organisms at the base of marine food-chains.

2. Materials and methods

Four water-based facial cleansers containing polyethylene were purchased at a supermarket in Auckland, New Zealand (brands A–D). The brands chosen were produced by major cosmetic manufacturers, <NZ\$15 per tube, and are readily available to consumers in the developed world.

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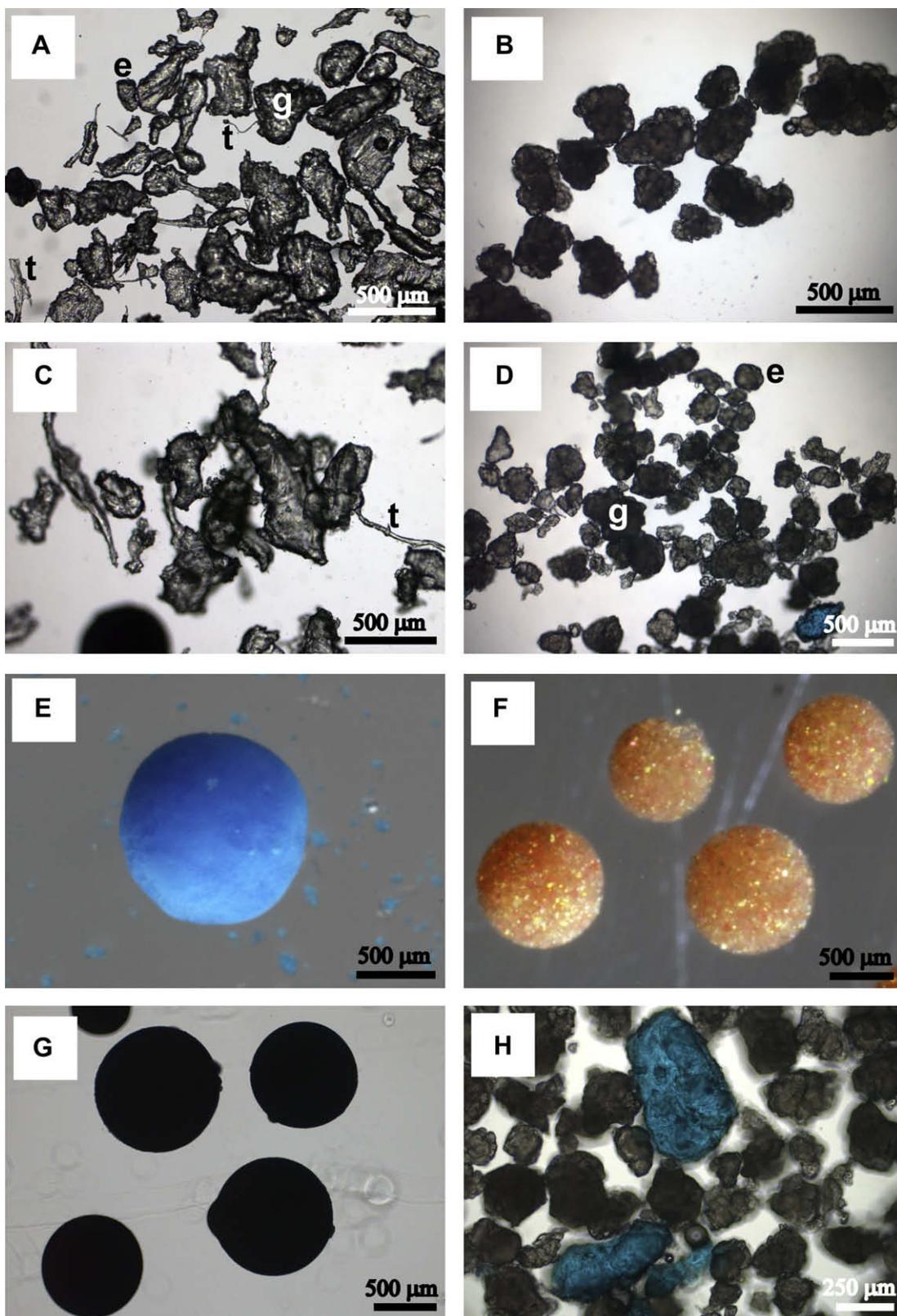


Fig. 1. Photomicrographs of the microplastics and coloured inclusions in facial cleanser brands A–D. Scale bar in all panels except H 500 µm. (A) Microplastics from brand A include variable irregular shapes that include granular particles (g), ellipses (e), and threads (t). (B) Microplastics from brand B are uniform and granular in shape. (C) Microplastics from brand C include variable irregular shapes that are rounded or thread-like (t). (D) Microplastics from brand D are uniform and elliptical (e) or slightly granular (g) in shape. (E) Blue coloured material from brand A. Product labelling refers to these as “pore cleansing power beads” that contain lactic acid to “help open clogged pores”. (F) Orange coloured material from brand B. Chemical composition unknown. (G) Blue coloured material from brand C. Chemical composition unknown. (H) Blue coloured material from brand D. Chemical composition unknown.

In order to extract the microplastic we added 0.5 g (wet weight, ww) of each product to 25 mL of 70 °C water in the barrel of a 30 mL plastic syringe, with the Luer lock fitting attached to a stainless steel 25 mm microsyringe filter holder (Millipore) containing an 8 µm nitrocellulose membrane filter (SCWP, Millipore). The syringe, with attached filter unit, was shaken vigorously for up to a minute to get the cleanser into solution. The temperature used, while slightly higher than might be used in face-washing (ca 40 °C), was required to get two of the four brands into complete solution.

The syringe was slowly discharged through the 8 µm filter, the filter was removed using filter forceps (Millipore), and the plastic was washed off the filter and into a small petri dish or directly onto a Sedgewick-Rafter cell using a laboratory squirt bottle. Size measurements were made using a calibrated eyepiece graticule on a Leica compound microscope at either 40x or 100x magnification. For each brand we used three replicate 0.5 g extractions and measured the lengths of the first 50 pieces of microplastic encountered in transects across the Sedgewick-Rafter cell (Total $N = 150$ pieces per brand).

Two of the brands, A and B, also contained larger sized bursting beads that burst in the hot water treatment, so were thus isolated in cold water. The coloured material in brands C and D were isolated in warm water.

3. Results

The microplastics contained in all brands of facial cleansers are not smooth and spherical, but show a variety of irregular shapes (Fig. 1A–D). Whereas brands B and D contained plastics fairly uniform in shape, plastic in brands A and C ranged from ellipses, ribbons, and threads, to completely irregular fragments (Fig. 1A–D). As the brands are manufactured in Germany, Korea, France and Thailand respectively, it is unlikely that there is a common source for the polyethylene microplastics contained in these cleansers.

Microplastics in the facial cleansers showed a wide size range, with few larger than 1 mm (Fig. 2a–d, Table 1). In all brands,

Table 1

Size of microplastic fragments in four brands of facial cleanser.

Brand	Median size (µm)	Size range (µm)	Shape
A	196.81	10.2–1075.0	Variable, includes ellipses, rods, threads
B	375.00	52.5–847.5	Uniform, granular
C	247.50	4.1–1240.0	Variable, irregular, rounded to thread-like
D	196.94	31.6–418.4	Uniform, elliptical, slightly granular

($N = 150$ fragments per brand).

the majority of microplastics were smaller than 0.5 mm, and in three of the four brands (A, C, D) the mode was <0.1 mm (Fig. 2). Brands A and C had the longest fragments, but as these long threads were generally very thin (Fig. 1A and C), their high surface area would make them likely to be quickly broken into smaller fragments.

In addition to the microplastics all brands included coloured material that did not appear to be constructed from plastic (Fig. 1E–H). Brands A and B contained large beads >0.5 mm which burst during face-washing (Fig. 1E and F). The product label on brand A referred to these as “pore cleansing power beads” that contain lactic acid to “help open clogged pores”. Brand C contained smaller beads that were not readily crushed, and brand D contained blue fragments that were similar in shape to the microplastics (Fig. 1G and H).

4. Discussion

Research on plastics pollution in the ocean has focused on the macroplastics fraction which affects at least 267 marine species by ingestion or entanglement (Derraik, 2002; Moore, 2008). Although macroplastics in the oceans are broken down into smaller pieces and therefore become available to more organisms for ingestion (Moore, 2008), here we have highlighted that the average consumer is directly releasing microplastics of a size suitable for ingestion by marine organisms without degradation.

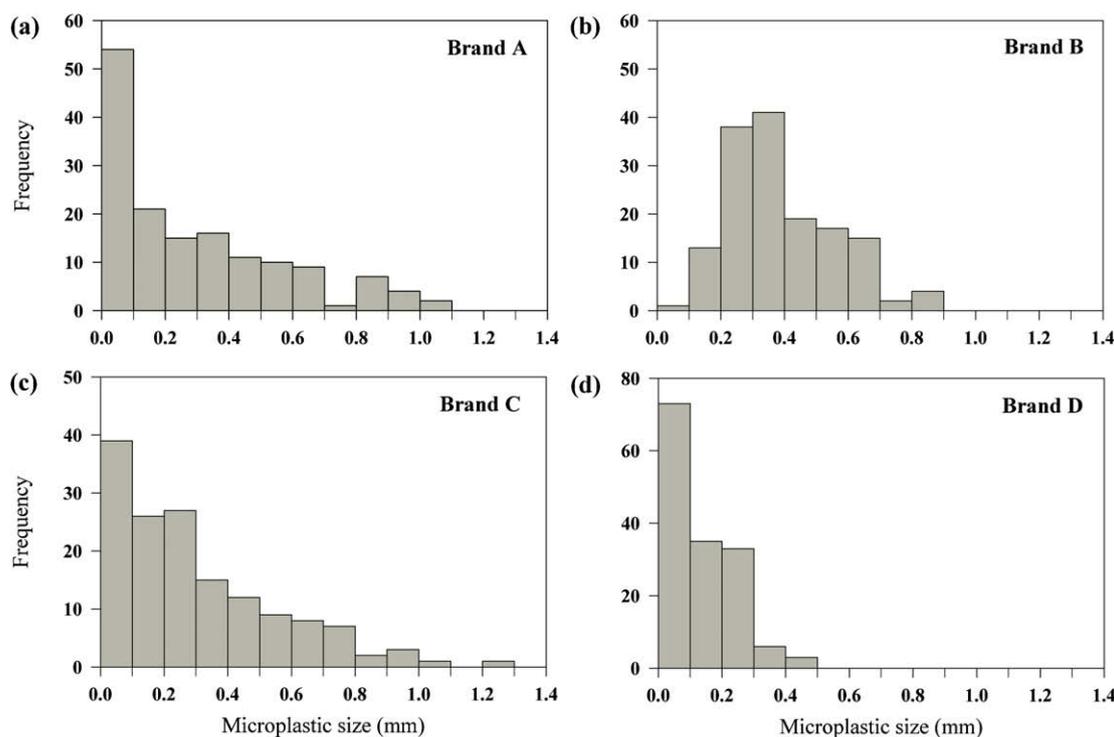


Fig. 2. Size frequency distributions of the microplastics from facial cleanser brands A–D. $N = 150$ fragments per brand.

The long-term impacts of microplastics on marine organisms are currently unknown. Small animals consuming microplastics are at particular risk from starvation, reduced food consumption due to satiation, or intestinal blockage leading to death (Derraik, 2002). Microplastics of the size shown here (<2 mm) can be ingested by filter-feeding polychaetes, echinoderms, bryozoans, bivalves and barnacles (Ward and Shumway, 2004; Thompson et al., 2004), deposit feeding lugworms (Thompson et al., 2004) and sea cucumbers (Graham and Thompson, 2009), and by detritivores such as amphipods (Thompson et al., 2004). More disturbingly, Browne et al. (2008) have recently shown that microplastics accumulate in the gut of filter-feeding mussels, are translocated to the circulatory system within three days of ingestion, and persist for more than 48 days.

The microplastics described here are polyethylene, which with a specific density <1 will float on the water surface (Eriksson and Burton, 2003), and be available to a wide variety of planktonic organisms feeding in the euphotic zone, as well as fish and seabirds that feed at the water surface. Microplastics are consumed by planktonic organisms (arrow worms, larval fish, Carpenter et al., 1972; salps, Moore et al., 2001) and plastic microspheres (0.01–0.07 mm) are consumed in laboratory feeding trials of copepods (Wilson, 1973) and invertebrate larvae (trochophores: Bolton and Havenhand, 1998; echinoderm echinoplutei, ophioplutei, bipinnaria and auricularia: Hart, 1991). Both the field collections and laboratory experiments suggest that microplastics of the size reported here (modal size <0.1 mm in 3/4 brands) would not be rejected by typical inhabitants of the euphotic zone.

If microplastics are ingested by small planktonic organisms such as copepods, there is the potential for the plastic to pass to, and accumulate, at higher levels of the food chain. For example, microplastics found in seal scat are believed to have been first accumulated in myctophid fish which feed on copepods of the same size as the plastic particles (Eriksson and Burton, 2003).

Two other areas of concern arise with respect to microplastics in the ocean. The first is that because synthetic polymers persist in the environment with minimal degradation (Moore, 2008), plastic debris remains in successively smaller fragments due to wave action, sand grinding, exposure to sunlight (Eriksson and Burton, 2003) and passing through the digestive systems of other organisms. Since many microplastics float, exposure to UVB radiation causes plastic polymers to become brittle and break apart, leaving smaller and smaller pieces until nanoparticles (Handy and Shaw, 2007) and even individual polymers are reached (Moore, 2008).

Secondly, plastic fragments in the ocean can bind and uptake toxic hydrophobic contaminants (Vom Saal et al., 2008), such as polychlorinated biphenyls (PCBs) on their surfaces (Rios et al., 2007; Teuten et al., 2007), and may be a vector for organic contaminants to enter food webs (Zitko and Hanlon, 1991; Derraik, 2002; Moore, 2008).

In conclusion, the presence of microplastics in facial cleansers, and their potential use by millions of consumers world-wide, should be of increasing concern to marine biologists. The size range of particles makes them available to small organisms low in the food chain, and their persistence in the environment means that microplastics become smaller and more toxic over time. As open ocean food chains depend on filter-feeding organisms such as copepods, arrow worms and salps, there is a high likelihood that once ingested by organisms low in the food chain, microplastics

will be accumulated in species of pelagic fish that are consumed by humans. We believe that microplastics in facial cleansers are largely unnecessary, and may result in long-term impacts to the marine environment.

In a recent editorial in *Marine Pollution Bulletin*, Galloway (2008) asked scientists to think about the use of plastics in their laboratories, encouraging us to “reduce, reuse, and recycle”. Here we ask scientists, and the households of which they are part, to be aware of the potential contribution to microplastics pollution made when washing one’s face.

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