Plastic microbeads in products and the environment

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Introduction

Plastics have many benefits for consumers and industry. As a result of their versatility, the use of plastics has increased twenty-fold in the past fifty years worldwide. However, it is estimated that there are over 150 million tonnes of plastics in the ocean today.[1]

Scientific evidence is rapidly growing on the impacts of plastics on the environment and the food chain, particularly in marine ecosystems.

A range of sources of plastics in the environment can be found, including plastic packaging, beverage containers, plastic bags, fishing lines, and 'microplastics'. 'Microplastics' are small plastic particles with an upper size limit of five millimetres in diameter. They include:

- plastic particles generated from the breakdown of larger plastic items
- fibres from acrylic and polyester clothing
- small purposefully manufactured plastic particles also called 'microbeads' (particularly in cosmetics, personal care and cleaning products). These are referred to as **microbeads** in this paper.

Action on plastics

In Australia, a number of initiatives have been introduced or are being proposed by the Government to address the impacts of plastics on the environment. For example, in NSW alone, there is:

- a five year $465.7 million *Waste Less Recycle More* grants program designed to rapidly increase recycling and reduce litter in the NSW
- a Container Deposit Scheme to be introduced in July 2017 to reduce packaging and containers entering the litter stream and the environment
- work being undertaken to develop a harmonised approach to reduce the environmental impact of plastic shopping bags
- research about to commence to assess how to minimise the impact of plastic clothing fibres on the marine environment.

These initiatives, however, are unable to address the environmental impacts of microbeads from cosmetics, personal care and cleaning products, which are designed to be flushed down the drain and are too small to be feasibly collected or recycled. In addition, the United Nations Environment Programme (UNEP) has identified that the key to solving the marine plastic problem is to take action at the source;[2] in other words, ensuring plastics do not reach the environment in the first place.

Scientific research

An extensive body of scientific research demonstrates the impacts of microbeads from cosmetic and cleaning products:

- Microbreads reach and persist in the environment in large numbers because they are in products which are designed to be 'rinsed-off' and flushed down the drain. They are not captured by most wastewater treatment systems. Those that are captured in wastewater treatment systems end up in the biosolids which are often then applied on land. A 2015 UK study (Napper and Thompson) estimated that between 4594 and 94,500 microbeads can reach the environment per use of just one facial scrub containing microbeads.[3]

[1] World Economic Forum, *The New Plastics Economy: Rethinking the future of plastics,* January 2016

[2] UNEP (2014) *UNEP Yearbook 2014 emerging issues update: Plastic Debris in the Ocean*

[3] Napper, I.E., Thompson, R.C. (2015) *Characterisation, quantity, and sorptive properties of microplastics extracted from cosmetics*, Marine Pollution Bulletin 99:178-185.

- Microbeads are almost impossible to remove from the environment, once they reach it, due to their size.
- They have the potential to cause harm in the environment and human health due to their composition, ability to attract toxins and to transfer up the food chain.

Action on microbeads

Because of these concerns, action is underway by both government and industry in Australia and worldwide. For example, the US Federal Government recently enacted the *Microbead-Free Waters Act 2015*, which prohibits the manufacture of rinse-off cosmetics containing microbeads from 1 July 2017, and their sale from 1 July 2018. Some product manufacturers and retailers have also either already phased out, or have publicly committed to phasing out microbeads from their products. In February, Canada published similar proposed regulations.

In Australia, the NSW EPA has coordinated a multi-disciplinary Microplastics Working Group to develop an evidence base to inform the most effective response to the issue. The work of this group was presented to the Meeting of Environment Ministers in December 2015.

At that meeting, the Environment Ministers from all Australian state, territory and federal governments agreed to work towards seeking a voluntary agreement from industry to phase out microbeads in personal care, cosmetic and cleaning products.

The aim of this paper is to provide information about plastic microbeads in cosmetic, personal care and cleaning products, their potential environmental impact, and what actions have and will be undertaken to address the issue.

Microbeads in products and the environment

This section explains how widespread microbeads are in products and the environment, and the nature of the environmental problem.

Use of manufactured microbeads in cosmetic and household cleaning products

The inclusion of microbeads in cosmetics, personal care and cleaning products has only become widespread in Australia in the past 20 years. Microbeads are now used in many common household products, including facial cleansers, body scrubs, soaps, toothpastes, hand washes, shampoos, commercial cleaning products, detergents, nail polish and sunscreen.

Microbeads are used as ingredients in these products for a variety of functional purposes. This includes their use as an abrasive (e.g. as an exfoliant), a bulking agent, for controlled timed release of active ingredients (for skin conditioning and oral care) and to prolong shelf life. They are also a relatively cheap ingredient.

The plastic microbeads in personal care products are generally polyethylene (PE).[4] However, they can also be polypropylene (PP), nylon, polymethyl methacrylate and other compounds.

The prevalence of microbeads in cosmetic and personal care products is demonstrated by the following:

[4] UNEP (2015) *Plastic in Cosmetics* – a 2012 survey by Cosmetics Europe, a leading European association representing he European cosmetics and personal care industry, found that polyethylene beads represented 93% of total use of microbeads in cosmetic/personal care products.

- A 2015 UK scientific study of facial scrubs found that the tested products could contain between 137,000 to 2,800,000 microbeads per bottle[5].
- The United Nations Environment Programme (UNEP) report entitled 'Plastic in Cosmetics', released in June 2015, stated that a typical exfoliating shower gel can contain roughly as much plastic in microbeads in the cosmetic formulation as is used to make the plastic packaging it comes in[6].
- A random sample initiated by Plastic Soup Foundation and North Sea Foundation in February 2016 identified over 100 personal care products containing microbeads which are available in Australia.[7] These products were mainly facial and body scrubs.

What is the problem?

The scientific research demonstrates that microbeads can reach the environment in large numbers and have the potential to harm the environment and human health due to a number of factors.

Microbeads are not captured by most wastewater treatment systems

Cosmetic, personal care and cleaning products containing microbeads are invariably designed to be used once and then rinsed off the body or cleaning area, and flushed down the drain. If they are not captured by wastewater treatment systems, they will likely enter into lakes, rivers and oceans. They may also enter the marine environment through transport/manufacturer spills or stormwater overflows.

A number of scientific studies have demonstrated the limited capacity of wastewater treatment plants to filter microbeads.[8] Wastewater treatment plants are designed to treat wastewater and break apart human waste, but have not been designed to filter microbeads.

For context, Sydney Water has confirmed that:

- Primary treatment plants can only capture particles to a size of five millimetres. Although this is effective at removing larger plastic items, it is not effective at removing the majority of microplastics such as microbeads. Primary treatment plants in Sydney process approximately 75% of Sydney's wastewater, and discharge to the ocean.
- Tertiary treatment plants can capture particles down to a size of 0.001 millimetres. Although there are some inland tertiary treatment plants in Sydney, the microbeads which are captured will then form part of the biosolids and sludge which are often applied onto land, re-entering the environment and potentially waterways. During significant wet weather events, these plants can only provide partial treatment.
- It is prohibitively expensive to convert primary treatment plants to tertiary treatment plants. It may also lead to a number of negative environmental consequences, including excessive transport of microbead contaminated biosolids.

Persistence and accumulation of plastic microbeads in the marine environment

One of the reasons plastics have replaced many natural products is because of their durability. Although positive from a manufacturing perspective, this is one of the reasons why they can cause harm once in the environment. Plastic is resistant to degradation, slow to break down and therefore accumulates in the environment.

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[5] Napper, I.E., Thompson, R.C. (2015) *Characterisation, quantity, and sorptive properties of microplastics extracted from cosmetics,* Marine Pollution Bulletin 99:178-185.

[6] UNEP (2015) *Plastic in Cosmetics*

[7] http://www.beatthemicrobead.org/en/product-lists

[8] German. Magnusson, K., Noren, F. (2014) *Screening of microplastics particles in and down-stream to a wastewater treatment plant*, IVL Swedish Environmental Research Institute.

In the case of microbeads in the marine environment, the time taken to break down may be further increased. Some evidence suggests this is because:

- the conditions may reduce the degradation rate, due to the relatively lower temperatures and oxygen concentration in water environments.
- a layer of micro-organisms can cover the plastic, further preventing contact with the elements that could degrade the plastic (the 'fouling effect').[9]

A 2013 study that sampled for microplastics in the Laurentian Great Lakes, USA found that microplastics were present in high numbers.[10] The average abundance was approximately 43,000 microplastic particles/km^2, with one sampling location downstream from a major city containing 466,000 particles/km^2. The study found that many of the microplastic particles were multi-coloured spheres, which were compared to and suspected to be microbeads from consumer products.

These findings appear consistent with on-going sampling being undertaken by the Ontario Ministry of the Environment and Climate Change. This work has found that on average, microbeads account for 14% of microplastics found in nearshore sites in Lake Ontario and Lake Erie.[11]

Plastic microbeads accumulate in the marine environment as they are too small and widely dispersed to be cost-effectively recovered once in the environment or recycled. Any remediation would likely also cause ecological damage to surrounding ecosystems.

One New Zealand study analysed the size of polyethylene microbeads in water-based cleansers, and found the majority were smaller than 0.5mm.[12] Photomicrographs of the microbeads can be seen below:

[9] Andray, A.L. (2011) *Microplastics in the Marine Environment*, Marine Pollution Bulletin, 62: 1596-1605.

[10] Eriksen, M., Mason, S., Wilson, S., Box, C., Zellers, A., Edwards, W., Farley, H., Amato, S. (2013) *Microplastic pollution in the surface waters of the Lauretian Great Lakes*, Marine Pollution Bulletin, 77: 177-182.

[11] See https://www.ontario.ca/page/microplastics-and-microbeads#microbeads

[12] Fendell, L.S., Sewell, M.A. (2009) *Contributing to marine pollution by washing your face: Microplastics in facial cleansers,* Marine Pollution Bulletin, 58: 1225-1228.

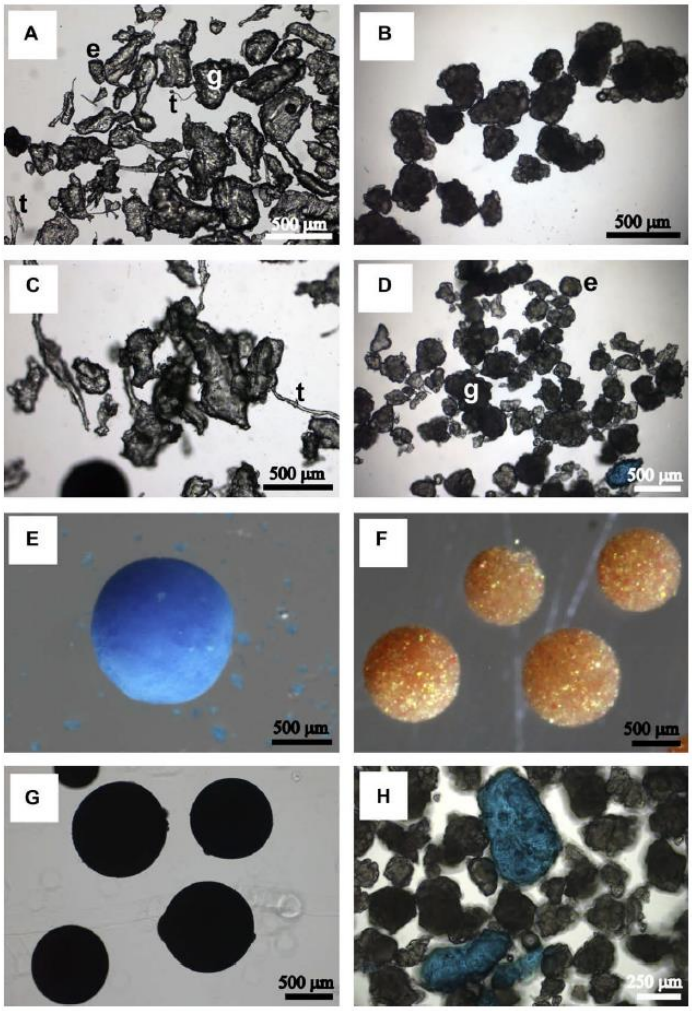

Figure 1: Fendell, L.S., Sewell, M.A. (2009) *Contributing to marine pollution by washing your face: Microplastics in facial cleansers*, Marine Pollution Bulletin, 58: 1225-1228.

Toxicity of plastic microbeads

The composition and relatively large surface area of microbeads make them prone to adhering organic pollutants from the marine environment. Persistent organic pollutants (POPs) are present in aquatic systems due to their widespread use, long range of transport, and persistence. POPs have a range of potential negative impacts on human health and the environment. High concentrations of POPs such as PCBs and DDT have been found on the surface of microplastics.

Particular plastics, such as polyethylene (the most common type of plastic in microbeads) are so good at attracting these pollutants that they are used as a sampling method in contaminated sediments and aquatic environments.[13] The organic pollutants will adsorb to the plastic, which allows the tester to determine what contaminants are present.

A field study by International Pellet Watch, a global monitoring program sampled microbeads in Foul Bay, South Australia. Of the first 100 pellets collected, 93 were polyethylene pellets

[13] Ghosh, U. *et. Al.* (2014) *Passive sampling methods for contaminated sediements: Practical guidance for selection, calibration, and implementation*, Integrated Environmental Assessment and Management, 10: 210-223.

with concentrations of PCBs (polychloroinated biphenyl) and DDT (dichlorodiphenyltrichloroethane) present.[14]

Once in the environment, microbeads can also leach plasticisers (chemicals that are added) that are toxic as they come into contact with UV and mechanical degradation. Diverse communities of micro-organisms have also been discovered colonising and thriving on microplastics, transporting potentially harmful microbes and algal species to new locations.[15]

Environmental and human health risks of microplastics

Research indicates that marine species are not able to distinguish between their usual food source and microplastics. Marine species have been shown to uptake these particles either via ingestion or filtration, potentially introducing toxins to the base of the food chain. Microplastics have the potential to transfer up the food chain, which may lead to consumption by humans.[16]

For example, a study tested the uptake and health impacts of polyethylene and polystyrene particles (free of contaminants) by a Mussel. Microplastics were taken up via the gills, and ingested into the stomach (see diagram below).[17] From there, they were taken up into cells, and translocated into the circulatory system. One study showed a significant inflammatory response.[18]

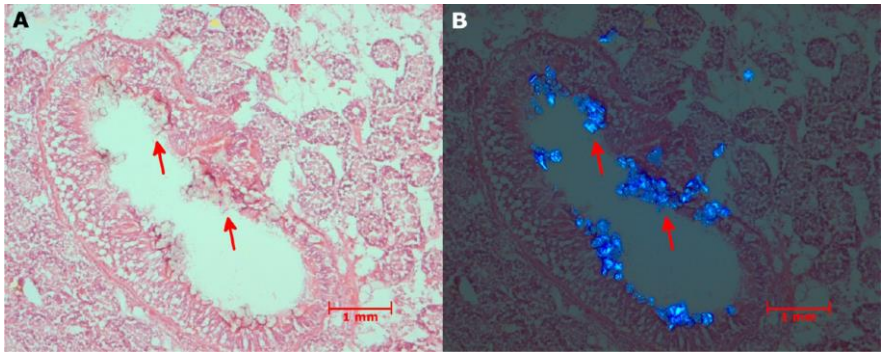

Figure 2: Moos, N.V., Burkhardt-Holm, P., Kohler, A. (2012) *Uptake and Effects of Microplastics on Cells and Tissue of the Blue Mussel Mytilus edulis L. after an Experimental Exposure*, Environmental Science and Technology, American Chemical Society Publication.

Another study conducted in the Great Barrier Reef demonstrated the impact of microplastics on coral reefs.[19] The study showed the presence of microplastics in coral reef waters adjacent to inshore reefs in the Great Barrier Reef. The study undertook feeding trials with

[14] Ogata, Y. *et. Al.* (2009) *International Pellet Watch: Global monitoring of persistant organic pollutants (POPs) in coastal waters. 1. Initial phase data on PCBs, DDTs, and HCHs,* Marine Pollution Bulletin, 58: 1437-1446.

[15] Cole, M., Lindeque, P., Halsband, C., Galloway, T.S. (2011) *Microplastics as contaminants in the marine environment: A review*, Marine Pollution Bulletin, 62: 2588 – 2597. Wright, S.L., Thomspon, R.C., Galloway, T.S. (2013) *The physical impacts of microplastics on marine organisms: A review*, Environmental Pollution, 178: 483 – 492.

[16] Wright, S.L., Thomspon, R.C., Galloway, T.S. (2013) *The physical impacts of microplastics on marine organisms: A review,* Environmental Pollution, 178: 483 – 492. . Cole, M., Lindeque, P., Halsband, C., Galloway, T.S. (2011) *Microplastics as contaminants in the marine environment: A review*, Marine Pollution Bulletin, 62: 2588 – 2597

[17] Moos, N.V., Burkhardt-Holm, P., Kohler, A. (2012) *Uptake and Effects of Microplastics on Cells and Tissue of the Blue Mussel Mytilus edulis L. after an Experimental Exposure,* Environmental Science and Technology, American Chemical Society Publication.

[18] Browne, M.A., Dissanayake, A., Galloway, T.S., Lowe, D.M., Thompson, R.C. (2008) *Ingested microplastic translocates to the circulatory system of the mussel, Mytilus edulis (L.)*, Environmental Science and Technology, 42: 5026-5031.

[19] Hall, N.M., Berry, K.L.E., Rintoul, B.L., Hoogenboom, M.O. (2015) *Microplastic ingestion by scleractinian corals*, Marine Biology.

coral and demonstrated that coral ingest microplastics at the same rate as their natural food, plankton, into the gut tissue.

There have also been a number of studies on whether microbeads or microplastics can transfer up the food chain:

- A study investigated the ability for microplastics to be transferred up the food chain. They exposed mussels to microplastics, and then fed the mussels to crabs. Microplastics were found in the stomach, ovary and gills of the crabs.[20]
- A 2014 study tested for microplastics in oysters and mussels commercially grown for human consumption. Microplastics were found in both. The study concluded that an average portion of mussels contained 90 particles and an average portion of oysters contained 50 particles.[21]

Precautionary principle

Although the body of scientific evidence is building, there are still data gaps in the research into microplastics. Understanding the complete lifecycle and full extent of impacts is a challenging task, particularly in the marine environment, due to the high variability of conditions.

However, the research demonstrates significant quantities of microbeads are reaching marine environments, with a variety of potential environmental impacts. UNEP released a paper in 2015 which found that 'Given the associated potential risks of microplastics, a precautionary approach is recommended toward microplastic management, with the eventual phase-out and ban'[22] in personal care and cosmetic products.

Industry and government response

In response to the growing evidence of the impact of microbeads on the marine environment, some governments and parts of industry have implemented measures to reduce the number of microbeads reaching the environment.

Product manufacturers and retailers – voluntary phase outs

There have been some significant and positive steps made by industry. Some manufacturers and retailers have either already phased out, or are committed to phasing out microbeads from their products. Other companies have made statements that they never have, and never propose to include microbeads in their products. There has also been significant work undertaken by not-for-profit groups such as Beat the Microbead and DoSomething! to educate industry and governments on the impacts of microbeads in the marine environment, and to encourage phasing them out in consumer products.

Although many cosmetics manufacturers and retailers have committed to phasing out or not using microbeads, there are limited public commitments from smaller businesses or online retailers. Further, some of the public commitments are specifically limited to polyethylene microbeads in personal care products.

It is also unclear from many of the commitments whether other plastics (including bio-plastics) may be used as an alternative. While some bio-plastics are 'biomass derived', this does not necessarily mean they have improved environmental degradation properties.

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[20] Farrell, P., Nelson, K. (2013) *Trophic level transfer of microplastic: Mytilus edulis (L.) to Carcinus maenas (L.),* Environmental Pollution, 177: 1-3.

[21] Cauwenberghe, L.V., Janseen, C.R. (2014) *Microplastics in bivalves cultured for human consumption*, Environmental Pollution, 193: 65-70.

[22] UNEP (2015) *Plastic in Cosmetics*

International approach

The impact of microplastics on the marine environment has received significant attention from regulators in various jurisdictions outside Australia:

> ***USA:*** In 2014 and 2015, a number of States in the United States of America legislated bans for microbeads in consumer products. In January 2016, the US Federal Government passed the *Microbead-Free Waters Act 2015*, which prohibits the manufacture of rinse-off cosmetics containing microbeads from 1 July 2017, and their sale from 1 July 2018. For non-prescription drugs, manufacture is prohibited from 1 July 2018, and sale from 1 July 2019.
>
> ***Canada:*** In February 2016 Canada published proposed Regulations for Microbeads in Personal Care Products Used to Exfoliate or Cleanse, under the *Canadian Environmental Protection Act 1999.* This will extend the range of possible tools that can be used by the Federal Government to reduce the release of microbeads into the environment.
>
> The proposed regulations would prohibit manufacture and import of microbead-containing personal care products from 31 December 2017, and prohibit sales from 31 December 2018. Regulations on non-prescription drugs and natural health products would be delayed by a year.
>
> ***Europe:*** The Netherlands, Austria, Luxembourg, Belgium and Sweden have issued a joint call to ban microplastics used in personal care products. The joint statement that has been forwarded to the European Union's 28 environment ministers stated that *the elimination of microplastics in products, and in particular, in cosmetics and detergents, is of utmost priority.*
>
> The European Union has commissioned a study to investigate various actions which could be implemented to reduce microplastics from cosmetic products entering the marine environment.

Australian approach

In August 2014, the then NSW Minister for the Environment announced support for action to be taken on microplastics, in response to increasing evidence of the widespread distribution of microplastics in the environment.

The NSW Environment Protection Authority (EPA) formed a NSW Microplastics Working Group to establish evidence-based options to manage the emerging issue. This Working Group included key stakeholders from government, industry, environmental groups and scientists. The working group has held multiple meetings, and an industry forum to provide the scientific evidence to industry for an open discussion.

The Working Group, led by the NSW EPA, conducted an extensive review of the scientific literature and the Australian market to establish the sources of microplastics and their impact on the environment, and provided an options paper to the NSW Environment Minister. This options paper was provided to the Meeting of the Environment Ministers (MEM) in December 2015. At that meeting, it was resolved by all State, Territory and Federal Ministers that:

> 'NSW and the Australian Government will lead further work to secure a voluntary agreement from industry to phase out microbeads in personal care, cosmetic and cleaning products. This will be considered at the next meeting, with a phase out period of two years following commencement of the agreement, but no later than 1 July 2018. Ministers agreed that they would consider further actions, if required to address outstanding products that contain microbeads.'

Voluntary industry agreement

The development of a voluntary industry agreement allows for the industry to take a proactive approach to actively manage the impact of microbeads in the environment, and demonstrate leadership without the need for a regulatory approach.

In response to the MEM resolution, the NSW Government and Australian Government have worked with ACCORD to develop a draft industry agreement which sets out terms for the national phase out of microbeads in cosmetics and cleaning products. ACCORD is the national industry association representing manufacturers and suppliers of hygiene, cosmetic and specialty products. ACCORD will represent industry in finalising this agreement.

On 29 February 2016, the Federal Minister for the Environment announced that 'If by 1 July 2017 it is clear that the voluntary phase-out will not achieve what is effectively a widespread ban on microbeads, the Federal Government will take action to implement a ban in law'. It is anticipated that if required, this could potentially be achieved through the Product Stewardship Act 2011.

The products captured by the voluntary agreement include cosmetic and personal care products and cleaning products containing plastic microbeads which are rinse-off products or otherwise reasonably capable of reaching the environment after use or disposal. This also includes sunscreens and toothpastes.

The proposed voluntary agreement would include phase-out periods which are closely aligned with the USA legislation in order to provide time for affected organisations to reformulate their products. Signatories also will be required to:

- commit to seeking to ensure that any replacement for plastic microbeads should not lead to adverse impacts on the environment on human health from commencement of the agreement
- report regularly on progress towards phasing out microbeads from the commencement of the agreement until 1 July 2018. This reporting mechanism would enable industry to report positively on those companies that are proactive as well as the need for revisions to the approach if the uptake is not sufficient.

Next steps

The voluntary industry agreement is open for feedback from industry until **31 July 2016.** All feedback should be communicated to ACCORD.