

Plastics: time for a rethink? Part I

Learning outcomes

This article is the first of two examining our relationship with plastics. Part I aims to assist the reader to:

- learn about the spread of plastics throughout the global environment;
- identify the possible health effects of plastics in humans; and,
- learn about international efforts to reduce plastic pollution.

Introduction

Polymers may be natural, such as rubber, horn or tortoiseshell, or may be synthetic, formed and moulded under pressure and heat, such as polystyrene or nylon. In the mid-19th century, the demands of industrialised manufacture resulted in an increasing scarcity of animal-derived products and the decimation of elephant populations in Africa and India due to the widespread use of animal horn in a range of utensils. It can be argued that elephants are not extinct because of the development of plastics – synthetic polymers – at the turn of the 20th century. Undeniably, the introduction of synthetic polymers was transformative due to their multiple uses, but now they are increasingly problematic. Where has it gone wrong?

Today, plastics are ubiquitous and mostly made from fossil fuels (Table 1). Plastics are now a major environmental problem found throughout the environment, in humans, and in an undetermined number of other creatures. Plastics are used in many different products, most of which are rarely reused. Furthermore, only a small amount of plastic waste is recycled and the remainder does not break down quickly in the environment.¹ The total production of plastic is increasing worldwide and stood at 459.75 million tonnes in 2019.² It is estimated that every year about 280 million tonnes of short-lived plastic products become waste.³ According to Greenpeace, plastic production is set to triple by 2060.⁴ Plastics are spread throughout the environment including the oceans, Arctic snow, Antarctic ice, in shellfish, table salt and drinking water. Plastics can also drift in the air and fall with rain in cities, towns and the countryside.

Microplastics are tiny shards of plastic measuring up to 5mm. These can be found in many products from tyres to cosmetics and beauty products. Microbeads are used as exfoliating agents in personal care products, including toothpaste and shampoos. These microplastics are designed to be rinsed down the drain and end up widely dispersed in the environment.

Table 1: Types of most commonly used plastics.

Types	Abbreviation	Applications
Polyethylene terephthalate	PET	Mouthwash bottles, food jars, water bottles, etc.
High-density polyethylene	HDPE	Detergent and bleach bottles, toys, etc.
Polyvinyl chloride	PVC	Windows, gutters, etc.
Low-density polyethylene	LDPE	Shopping bags, packaging film, etc
Polypropylene	PP	Bottle tops, straws, etc.
Polystyrene	PS	Cups, drinking straws, yoghurt containers, etc.

Others include nylon fabrics, compact discs, medical storage containers, etc.

Nanoplastics (nanoparticles of plastic) are the tiniest specks of plastic, smaller than 1 micron. These cause researchers the greatest concern as they are very difficult to isolate from the environment and so little is known about their potential effects.

Plastics may also have detrimental effects through chemical toxicity. Manufacturers add various compounds such as plasticisers, stabilisers and pigments to plastics. Some of these substances are hazardous and some are endocrine disruptors. These chemicals were assessed as contributing to disease and disability in a 2018 study that calculated the disease burden and cost due to chemicals used in the production of plastic materials in the United States.⁵ The authors estimated that the disease and social cost amounted to 1.22% of gross domestic product.

Environmental effects of plastics

The production of plastic is a very energy-intensive process. Plastic is made from fossil fuels such as oil, which is transformed using heat and other additives to make a polymer. In 2019, plastic accounted for 1.8 billion tonnes of greenhouse gas (GHG) emissions, which is 3.4% of the global total.³ This is more GHG emissions than the total emissions from flying worldwide (about 2%).

Animals in the sea can swallow plastic, including bags, or become trapped by plastic. This can lead to starvation or drowning. It is estimated that 100,000 marine mammals are killed each year by plastic pollution,⁶ and 81 out of 123 marine mammal species are known to either have eaten plastic or been entangled by it.



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Evidence is slowly accumulating of the dangers of plastic pollution in the environment. A new disease that is solely caused by plastics has been discovered in seabirds. The disease, plasticosis, causes extensive scar formation in the birds' digestive tracts.⁷ Microplastics can reduce the growth rate of zooplankton, which are a crucial element in the marine food chain, and they also cause zooplankton to reproduce less successfully.⁸

In the EU, 80-85% of marine litter is plastic as measured by beach litter counts, with single-use plastics representing 50% and fishing-related litter representing 27% of the total.⁹ Single-use plastic products and plastic fishing gear pose a severe risk to marine organisms and ecosystems, biodiversity, and human health, and cause damage to activities such as tourism, fisheries and shipping.⁹

Plastics do not break down easily in the environment as bacteria do not generally attack plastics. They will break down if exposed to sunlight. Photodegradation occurs when UV light hits plastic and causes the bonds that hold the long molecular chain together to break. Over time, this process can lead to a large piece of plastic turning into many little pieces. Some of the chemicals added to plastics, as mentioned above, can extend the life of plastic waste, with some estimates claiming a lifespan of up to 400 years before breakdown.¹

Health effects of plastics

Plastics exist not only in the environment but also in humans. Plastic particles can be ingested, inhaled and, to a lesser extent, absorbed through skin contact. We ingest plastics that are found in vegetables, salt, beer, fresh fruit and other foods, as well as water. We inhale plastic particles that come from car tyres and other sources. Very small particles, such as nanoplastics, can spread around the body and stay there. Studies in mice have shown that microplastics can stay in the intestines and reach the liver.¹⁰ It is estimated that a person might accumulate several thousand microplastic particles during a lifetime.¹¹ This may be an underestimate, as an earlier study suggests that the average person eats at least 50,000 particles of microplastic per year.¹²

A recent study has found that 4,200 chemicals used in plastics, including raw ingredients and additives such as stabilisers and colourants, can persist in the biosphere, are mobile, and some are toxic.¹³ Air pollution, including particulate pollution by polymers, causes about seven million deaths annually worldwide.¹⁴ Particulate plastic from tyres alone, for example, contributes to the pollution of land, air and water.¹⁵

Microplastic particle pollution was first detected in human blood by Leslie *et al.* in 2022.¹⁶ Blood samples analysed from 22 healthy donors showed that 80% (n=17) had plastic particles in their blood. This demonstrated that particles can travel around the body and be deposited in organs. Furthermore, a recent study of 304 patients undergoing surgery found that about 60% had microplastics or nanoplastics in a main artery.¹⁷ Those who had plastics in their artery were 4.5 times more likely to have a heart attack, stroke or die in the 34 months after surgery than those whose arteries were plastic free. These studies contribute to the body of evidence that microplastics may be an environmental determinant of health as suggested by the Public Health Subcommittee of The European Parliament.¹⁸

A recent press release from the Endocrine Society in the US calculated that US health costs related to chemicals in plastics reached \$250 billion in 2018.⁵ Some of the chemicals used in plastics, especially endocrine-disrupting chemicals, leach out of plastics and contaminate humans and the environment.

These chemicals disturb the hormone system and can also result in cancer, diabetes, reproductive disorders, and neurological problems in the developing foetus and in children.¹⁹

A pre-print paper that has been published online by the National Institute of Health (not yet peer reviewed) shows that researchers found microplastics in brain samples.²⁰ The 91 brain samples contained about 10-20 times the amount found in other organs. Brain tissue is one of the most plastic-polluted tissues and 24 of the brain samples collected had a plastic content of 0.5% by weight. The 12 brain samples from people who died from dementia had up to 10 times more plastic by weight than healthy samples. The study also noted that brain samples from 2024 had about 50% higher microplastics content than samples from 2016. This suggests that the amount of plastic found in human brains is increasing at a worrying rate. Recent studies have revealed the deleterious effects of microplastics exposure in male reproduction and sperm quality, making them a potential hazard to global fertility.^{21,22}

We still do not know how much damage to human health is caused by plastics but a cautious approach would be wise given the increasing amount of evidence of the health effects of plastic. However, the environmental damage is well documented. We must reduce the amount of plastics in the environment to reduce both the environmental and health effects.

What is being done to reduce plastic pollution?

A resolution was agreed in 2022 by UN member states to end plastic pollution. An intergovernmental negotiating committee aims to have a legally binding agreement on plastic pollution by the end of 2024. The talks are focusing on the life cycle of plastics from extraction of constituents to production of plastics and waste management. The long-term aim is to design out, as far as possible, the use of plastic before it is made as a part of the circular economy. However, European plastic waste is growing faster than economic growth and this is not in line with the EU's goal of reducing plastic waste.⁹

EU Directive 2019/904 on the reduction of the impact of certain plastic products on the environment, was published on June 5, 2019.²³ This Directive is primarily aimed at single-use items such as cotton buds, balloons, cups, cutlery, food, plastic bags, wet wipes, beverage containers, packets and wrappers. However, progress is slow and there is some push back against the Directive from plastics manufacturers.⁵ Suggestions by the EU and UN include:

- using innovation and incentives so that businesses can get rid of unnecessary plastics;
- taxation to reduce the production of single-use plastics;
- tax breaks, subsidies and other incentives to encourage alternatives such as reusable products;
- action at the individual level through avoiding plastic use or reusing as much as possible where it cannot be avoided; and,
- recycling or disposal of plastic in as sustainable a manner as possible – the plastic bottle deposit and collection scheme recently introduced in Ireland is an example of a system that will aid plastic recycling.

While this pollution disaster requires systemic reform, and there is a limit to what individual dental practices and dental teams can do to reduce plastic, we each have a contribution to make. The next article in this series will examine the use of plastics in the dental practice and look at ways of reducing their use, and the recycling of plastics.

Take-home messages

- Plastic pollution is ubiquitous in our environment;
- plastics are very damaging to wildlife;
- the health implications of plastics for humans are not certain, but increasing evidence suggests that they may be considerable;
- microplastics and nanoplastics will stay in the environment for several hundred years; and,
- international efforts to reduce plastic use have so far failed.

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