

Microplastics – The unseen dangers

Plastics and related polymers are one of the wonders of the 20th and 21st centuries. They are almost ubiquitous and are found in products used in research, healthcare, packaging, consumer goods, dental materials, transport and many more.

While the stability of plastics to environmental degradation has been one of their strengths, this persistence has been an important factor in their demonisation – there are few ‘end of life’ strategies for removal of waste plastic and the visible signs of discarded bulk plastic can be seen on land and in the sea. In addition, plastic use is both profitable and growing and the impact of post-use plastic is increasing.

The environmental impact of large deposits of plastics can be seen; however, the discovery of microscopic plastic particle that cannot be seen by the naked eye and are derived from synthetic (and even biodegradable) plastics has created new areas of concern for health and for the environment. The impact of these microplastics on health and the environment is still being assessed and there are numerous unanswered questions regarding the possible effects of these unseen microscopic particles and what mitigation strategies might be required to reduce the potential for deleterious consequences of their production.

Definition and sources of microplastics

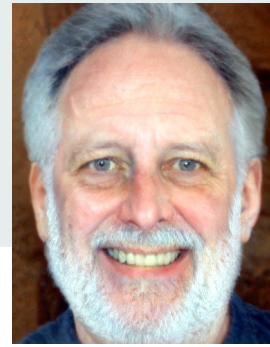
The sources of microplastics are bulk plastics and functional microplastic materials added to cosmetics etc. The term microplastics is used to describe plastic particles of less than 5mm in length and was first introduced by Thompson et al in 2004¹. Because of their small size and biostability, microplastics can enter cells and their potential biological effects at sub-cellular level are suggested to be of particular concern. It should be noted, however,

that most microplastics are considerably larger than, for example, asbestos fibres (about 20,000 times larger) and so the effects ascribed to asbestos are less likely to be manifest. However, it should also be considered that a lower limit for the size of microplastics has not been defined (see Analysis and Quantification of Microplastics) and there have been relatively few studies of their potential mechanisms of toxicity based on particle size or chemical composition².

The growth in the production of the inadvertent microplastics ‘starting materials’ (half of all plastic ever made has been produced since 2010) suggests that microplastic production from post-use plastic has probably not yet reached a peak level.

As noted above, microplastics can either be incorporated intentionally to impart a desired functional property (for example, in cosmetics, tooth pastes, detergents or paints) or can be produced from the physical, chemical or biological degradation of bulk polymers such as the tyres of vehicles, the grinding of dental materials³ or the production of ash from the incineration of plastics. Of these, tyre-derived microparticle release generated by shear forces between the tread and the road or by volatilisation contributes from one-third to half of microplastics unintentionally created and released into the environment⁴.

All of the different potential production routes for microplastics have not yet been delineated and this is a knowledge gap that has to be addressed in order that any mitigation measures can be assessed for ease of application and prioritised in terms of impact.



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Analysis and quantification of microplastics

The development of harmonised and cost-effective methods for the analysis of microplastics in a range of environmental and tissue matrices is a priority⁵. Most methods rely, at some stage, on microscopic analysis using visual or spectroscopic methods. While a range of methods of varying degrees of precision are available, the question of which are ‘fit for purpose’ in terms of cost, time taken for analysis, level of automation that is possible and the required sample preparation remains to be confirmed. In addition, different bulk plastics will produce different microplastics (both in terms of physical and chemical properties) and the extent to which the composition of individual microplastics must be determined (and the potential physiological and environmental effects of mixtures of microplastics) is unknown.

Potential health and environmental effects of microplastics

One of the most significant knowledge gaps concerns the potential biological and environmental effects of microplastics, the mechanisms that underpin these effects and if any effects are species-specific. Ingested substances undergo four processes – Adsorption, Distribution, Metabolism and Excretion (ADME) and the balance of these treatments defines the toxicokinetics of the compounds. Even the route of exposure (commonly inhalation or ingestion from food or other oral routes) can affect the toxicokinetics and, in turn, the risk of deleterious effects. Some types of microplastics (those derived from polystyrene and polyethylene, in



**Micro plastics mixed in the sand
in Famara beach, Lanzarote**

Photo Credit: GaiBru Photo

particular) have been associated with organ-specific physiological effects but studies are incomplete and a range of test systems (animals, in vitro cell models etc.) have been used. Effects on a range of clinical endpoints have been noted however in many cases comparisons between experimental systems (and data) is not possible and a quantitative risk assessment of microplastics from different bulk plastics with different chemical and physical (e.g. shape of the particles) has not been carried out. Microplastics may also have different effects on different ecosystems and this variation is not obvious simply by inspection.

Possible mitigation strategies

A number of potential mitigation strategies have been proposed. For those products that contain added, functional microplastics, reformulation to remove the necessity of having microplastics in the product can be suggested. For microplastics produced from bulk plastics the combination of removal of those materials most prone to producing microplastics during use and post-use processes can be advised. However such interventions can only be effective if more complete knowledge of the toxicological and environmental consequences of microplastics is available. The removal of microplastics from air, food and water has been proposed as a post-formation strategy.

Conclusions and next steps

Microplastics represent an acknowledged possible toxicological and environmental hazard. Control of the risk associated with exposure to microplastics will require a number of gaps in the knowledge base to be filled. These include the following:

- The development of appropriate, cost effective and harmonised procedures for the analysis and quantification of microplastics.
- A detailed analysis of the different sizes and shapes (smooth, irregular etc.) of microplastics and the biological consequences (including ADME studies) of the production of types and sizes of particles.
- The carrying out of ADME and toxicokinetic studies of microplastics by size, shape (see above) and chemical composition.
- The development of a better understanding of how different types of microplastics are formed from bulk plastics and the dependence of this on factors such as the degree of micro crystallinity or amorphous nature of the bulk material.
- The development of methods (e.g. filters etc) to remove microplastics from, in particular, air and water in a cost effective and efficient manner.

- Based on the above, the development of a suite of appropriate microplastic control methods.
- In addition, new methods of manufacture (including the synthesis of biodegradable plastics), should be assessed for their potential to produce microplastics⁶.

References

- ¹ Thompson RC et al (2004) Lost at sea: where is all the plastic?. *Science* 304, 838–838. DOI: 10.1126/science.1094559
- ² Wieland S et al (2022) From properties to toxicity: Comparing microplastics to other airborne microparticles. *J Hazard Mater.* 428:128151. doi.org/10.1016/j.jhazmat.2021.128151
- ³ Chandran T, Vishnu U, Warriar AK (2021) Microplastics in dentistry – a review. In: Muthu SS (eds) *Microplastic Pollution. Sustainable Textiles: Production, Processing, Manufacturing & Chemistry*. Springer, Singapore. doi.org/10.1007/978-981-16-0297-9_6.
- ⁴ Giechaskiel B et al (2024) Contribution of road vehicle tyre wear to microplastics and ambient air pollution. *Sustainability* 16 (2), 522. doi.org/10.3390/su16020522.
- ⁵ Pimpke S et al (2020) Critical assessment of analytical methods for the harmonized and cost-efficient analysis of microplastics. *Appl Spectrosc.* 74(9) 1012–1047.
- ⁶ Tong H et al (2022) Micro- and nanoplastics released from biodegradable and conventional plastics during degradation: formation, aging factors, and toxicity. *Sci Total Environ.* 833:155275. doi.org/10.1016/j.scitotenv.2022.155275