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The Ins and Outs of Microplastics

The global challenge associated with the mismanaged release of plastic waste is significant, threatening the ecological integrity of our oceans and land. Plastics can degrade and abrade over time and fragment into microscopic particles known as microplastics (defined by the European Commission as measuring <5 mm, with those measuring <0.0001 mm considered nanoplastics). These particles have been found in all environments. Their ubiquity, which is related to the environmental persistence of solid synthetic organic polymers, has led to widespread concern about their potential effects. These concerns are supported by evidence that ingestion of microplastics by a range of biota under laboratory conditions leads to reduced feeding activity, energy reserves (1), and fecundity (2). The potential for humans to be exposed to microplastic particles and fibers, as well as internalized chemicals that are associated with their manufacture (for example, flame retardants and phthalates) or absorbed on their surfaces in the environment (for example, organochlorine pesticides and polycyclic aromatic hydrocarbons), has been highlighted by the observation of microplastic contamination of seafood, sea salt, and bottled water (3). These sources suggest various routes of exposure via the diet, including contamination during processing, from packaging or atmospheric fallout, onto the food we eat. Ingestion of microplastics therefore seems inevitable, with back-of-the-envelope calculations estimating that the average adult consumes 39 000 to 52 000 microplastics each year via their diet alone (3). However, there are no studies showing distribution and effects of microplastic consumption in humans. These are major knowledge gaps that prevent an accurate assessment of the hazards posed to humans by microplastic consumption.

In their article, Schwabl and colleagues begin to address the fate of ingested microplastics by examining whether they can be detected in human stool (5). Unsurprisingly, they can be; after all, a proportion of what goes in should come out. This observation is an important steppingstone to more pressing questions. How many are retained? For how long, and at what cost to gastrointestinal and overall health? Although the study represents preliminary work that largely focuses on establishing a robust method for stool sampling and microplastic identification, the findings suggest a wide range of microplastic particle numbers in individual stool samples, ranging from 8 to 416 (median, 20) per 10 g of stool. The authors have wisely not attempted to explore these differences with reference to the dietary information collected given the small sample, but the variation suggests that a more comprehensive study would require more participants, longitudinal sampling, and more quantitative assessment of microplastic intake. The current food-based exposure estimates are simplistic and should be interpreted with extreme caution. They highlight sources, but the products that were assessed represent only 15% of an American's caloric intake (3).

Accurate estimation of the number of microplastic particles, films, and fragments is also subject to significant methodological challenges, as described in the article. Harsh digestions are needed to purify biological matrices to permit microplastic detection and could lead to underestimation due to complete disintegration of fibers (6) or overestimation due to degradation of large particles and fibers into smaller fragments. This may explain the relative absence of fibers detected in the stool samples despite fibers often being the most common microplastic shape observed in the environment. Furthermore, overcounting could arise due to overlap in analyzed subareas of sample filters, resulting in an area larger than the original filter being analyzed. Correlating spectral data against plastic-only references may increase the chance of false-positive results, and visually discriminating between similar polymer spectra (such as polybutylene terephthalate and polyethylene terephthalate) could result in misclassification. Much work is still required in this area, and analytic techniques capable of detecting plastic particles at the nanoscale are needed.

Although there is a danger in simplistic calculations of annual intake from various foodstuffs, we cannot help trying to extrapolate the annual microplastic excretion from the study participants. Considering that an average adult stool weighs 100 g and assuming 1 bowel movement per day, we estimate an annual elimination of 29 200 to 1 518 400 microplastics (median, 73 000), compared with the estimated annual intake of 39 000 to 52 000 (3). Measurement uncertainty aside, this would imply more elimination than intake, suggesting either overcounting in the stool or an alternative microplastic source that is not represented in the current estimate.

A key source outlined in the article is atmospheric fallout onto consumed foods (4). This raises a question about the fate of the inhaled fraction that is too large to penetrate to the distal lung but is eliminated from the nasopharyngeal region by impact into the protective mucus layer. This material is typically swallowed and could therefore be a significant additional source. Given published indoor (1.7 to 16.2 particles per cubic meter) (7) and outdoor (0.3 to 1.5 particles per cubic meter) (8) microplastic concentrations in ambient air, and using conservative assumptions of 10% and 90% of time spent in outdoor and indoor environments, respectively, and resting ventilation of 6 L/min (equivalent to 3 153 600 L/y), we estimate an additional gastrointestinal burden of 4920 to 46 453 microplastics per year. This is roughly equivalent to that obtained from the diet and would result in an overall intake greater than the median annual elimination rate derived from

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Schwabl and colleagues' study. This is important because, from a health perspective, the important particles are those that are retained in the gut mucosa and are likely to be involved in triggering local immune responses and downstream adverse effects. Starch particles up to 130 μm have been documented to cross the human gut wall via persorption (9), but at a very low rate (10). The concern is whether the size distribution of microplastics observed in stool accurately reflects exposure or a smaller size fraction (<50 μm) is being retained.

There is therefore an urgent need to not only accurately quantify intake and elimination rates but also focus on potential evidence of microplastic accumulation in the gut or at sites where biopersistent particles and fibers are likely to accumulate in the body, such as the lymph nodes. This will become increasingly important as plastic production and consumption, and therefore the ins and outs of microplastics, continue to grow.

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