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Plastics:
Problems and Solutions – Part 1

Microplastics in drinking water, food, and everyday products

The extensive accumulation of synthetic plastic products and particles in our environment is evidence of the problem of plastic pollution on Earth.[1] Plastic waste has become so endemic that it now appears everywhere, from urban and rural settings to the most remote and previously pristine areas of the world. An analysis of the growth of global plastic production over the past 70 years reveals the true extent of plastic pollution on Earth.

Since the advent of mass production in the 1950s, global production of plastics has grown from 1.5 million metric tons to a staggering 368 million metric tons,[2] while fewer than 10% of plastic waste has been recycled since then.[3] This increase shows that the soaring demand for plastic over the years has not been matched with the proper disposal of the plastics produced. This inconsistency stems from the durability of plastics, which while providing robustness and resistance, also hinders the ability of plastics to be broken down into new products, ultimately requiring new plastics to be created from oil every year to satisfy demand.

While much of the world's attention is focused on the large pieces of plastic that visibly pollute our environment, scientists have revealed the existence of billions of microplastic particles in our environment that are even more ubiquitous than the larger plastic items we see in our surroundings. The microplastic particles in question are tiny pieces of less than 5 millimeters in size that result from the natural fragmentation of plastics caused by degradation and UV exposure. The main concern for scientists is that, aside from originating from larger plastics manufactured with toxic compounds, microplastics are themselves chemically active

materials that are capable of attracting other potentially harmful compounds to their surfaces. Among the toxins that have been shown to accumulate on the surface of microplastics are metals such as lead and cadmium, toxic industrial compounds such as phthalates, bisphenols and polychlorinated biphenyls (PCBs), and pesticides.

Chemically active plastics in our homes

Given the lack of information concerning the dangers of microplastics, individuals lack awareness regarding the different sources of exposure to plastic pollution that exist in their daily environment. Many may not know it, but some of the biggest sources of microplastics released in our homes are from common items such as plastic kettles, plastic water bottles, and plastic infant-feeding bottles.

According to a recent study at Trinity College Dublin, plastic kettles made from polypropylene, a plastic commonly used in kitchen appliances, release 10 million microplastic particles when 1L of water is boiled at above 100ºC.[4] This is a very significant finding, because it provides evidence that water boiled with plastic kettles can be contaminated with plastic particles invisible to the naked eye. According to this same study, infant-feeding bottles release approximately 16 million microplastics during sterilization when at temperatures above 70ºC, which means that, unless cool sterile water is used to rinse sterilized feeding bottles before filling them with milk, babies that feed from plastic baby bottles could be ingesting millions of tiny plastic particles. Given that plastic baby bottles make up more than 80% of the baby bottle market around the world, the above findings have certainly raised concerns among parents.

Other worrisome findings relate to microplastics in bottled water. In a study conducted by the State University of New York at Fredonia, scientists analyzed 259 water bottles from 11 different brands across 9 countries and found microplastics in 90% of the samples.[5] The most common type of plastic found was polypropylene, which is used in the manufacturing of bottle caps. In one bottle of Nestlé Pure Life, the researchers found as many as 10,000 plastic particles per liter of water. Based on this study, the researchers estimated that the levels of plastic fibers in popular bottled water brands could be twice as high as those found in tap water.

The problem of microplastics in bottled water is further intensified in the presence of extreme heat given that chemical bonds in plastic products tend to break down when exposed to intense temperatures. According to different studies, water bottles made of polyethylene terephthalate (PET) have been found to release concerning doses of antimony, a highly toxic chemical, when heated above 60ºC.[6] Other products made of PET such as silky tea bags have also been found to release microplastics when exposed to high temperatures. A study from McGill University in

2019 found that PET tea bags release 11.6 billion microplastics and 3.1 billion nanoplastics at brewing temperatures of 95ºC.[7] This is of particular concern for Canadians, who collectively drink about 10 billion cups of tea a year.[8]

Other sources of exposure to microplastics in our homes have been linked to the food packaging industry. Plastic wrap, for example, is highly problematic. Often made of PVDC, PVC, or PET, plastic wrap releases highly toxic chemicals when it breaks down, potentially introducing great amounts of microplastics into our foods.[9] Food packaging such as takeaway and delivery plastic containers are also a concern because the heat released by the food can cause chemicals to break down, potentially leaching into our meals. Generally, the main containers to avoid are those made of polystyrene (PS), better known as styrofoam, as this material is a known carcinogen and also difficult to recycle. The American Academy of Pediatrics urges consumers to avoid all plastic products made of PS, represented with the recycling number 6, as well as those made from polyvinyl chloride (PVC), recycling number 3, and other polycarbonates, recycling number 7.[10] These products are made from these materials could release chemicals like styrene, whose exposure is linked to depression and fatigue, phthalates, which can damage the liver, kidneys, lungs, and reproductive system, and BPA, which is associated with cancer, metabolic disorders and infertility. This last chemical is also utilized in the lining of aluminium cans despite evidence that it acts as an endocrine disruptor.

All in all, the sources of microplastic release in the home are very extensive. Even microwave-safe plastic packaging is not completely safe, as standards demand the amount of chemicals leaching from containers to be lower than a specific maximum allowable amount, meaning that any amount lower than the maximum can technically be considered safe.[11] The most surreptitious sources of exposure in the home are perhaps building materials such as vinyl floors, furniture coated with flame retardants and electronics and children's toys laminated with toxic substances. A 2018 Swedish study showed that pregnant women living in homes with vinyl floors in their homes had higher levels of phthalates in their urine as compared to pregnant women living in homes with other flooring materials.[12] The women were exposed to the toxic substances because these had migrated from the products, they were part of into the surroundings of the home. Previous studies have found microplastics in the placentas of unborn babies, highlighting the dangers of a mother's exposure to plastic pollution and raising concerns over whether chemicals in microplastics could cause long-term damages to a fetus' developing immune system.[13] On a similar note, a study from Duke University published in 2019 found traces of harmful toxins in the urine and blood of children living in homes with vinyl flooring and sofas that contain flame retardants. Children who lived in homes where the sofa was in the living

room had 6 times higher concentrations of flame-retardant polybrominated diphenyl ethers (PBDEs) in their blood serum, and children living in homes with 100% vinyl flooring had 15 times more benzyl butyl phthalate in their urine. Some of the potential effects of exposure to PBDEs and benzyl butyl phthalates in include diabetes, liver problems, thyroid disease, respiratory problems, and disruptions of endocrine functions.

Scientists vs. The plastic industry

Plastic manufacturers use additives such as PCBs, pesticides and flame retardants to manipulate plastic to increase flexibility, durability and transparency. The use of polymers such as phthalates, BPA, and PVC is particularly concerning given the disturbing evidence found in animal trials with regards to exposure to these chemicals.

Phthalates are plasticizers commonly used in baby toys, food processing equipment and materials, medical devices, and vinyl building products, in addition to other items. Recent research has shown that toys contain over 100 substances including phthalates, plasticizers and flame retardants that could potentially harm children's health.[14] Although the effects of phthalates on human health is still unknown, animal research on the effects of phthalate ingestion has shown direct impacts on sperm development and testicular damage on rats, mice, and guinea pigs.[15] For humans, phthalates are suspected to damage male reproductive health and affect neurodevelopment outcomes in children, including lower IQ, and problems with attention, hyperactivity, and poorer social communication.[16] Scientists from expert groups are collaborating to gather evidence of the impact of these chemicals on brain development in children with hopes of raising awareness about the dangers of early life exposure to these chemicals.[17] According to a 2017 study exploring the effects of lifelong chemical exposure on human sexual development and fertility, poorly regulated chemicals leaching out of consumer products and escaping from agricultural and industrial uses have already started driving sperm counts down among males.[18] Environmental and reproductive epidemiologist Shanna Swan, who led the study, found that sperm counts in the Western world had plummeted by 59% between 1973 and 2011 due to the continued exposure of "everywhere chemicals" found in plastics, cosmetics and pesticides. Based on this study, the cumulative effect of exposure to phthalates is predicted to drive down sperm counts to zero by 2045, unleashing a serious fertility crisis with the potential of endangering the human species.

Bisphenol-A (BPA) is used to make a harder type of plastic, and it is most often found in products like plastic food containers, plastic utensils, aluminium cans, and sales receipts. This chemical is known by the medical community as an endocrine disruptor, as it is believed to interfere with normal hormonal function in humans and animals. A 2012 study from Harvard University examining the effects of BPA in monkeys found that BPA exposure levels comparable to those of humans caused disruptions in the specimens' reproductive systems, namely diminished egg quality and decreased fertility.[19] Literature reviews on the human health effects of BPA exposure have demonstrated links between the chemical and the development of health issues such as breast and prostate cancer, diabetes, obesity, infertility, and metabolic disorders.[20] It is also believed that endocrine disruptors trigger and/or worsen chronic diseases.

Polyvinyl Chloride (PVC) is used for different applications depending on its form, which can be rigid or flexible. It is most commonly used in construction, but it can also be found in shower curtains, clothing, and flooring, among others. This polymer is considered toxic due to its high chlorine content and can cause health effects like respiratory problems when combined with phthalates.

Despite concerns by the scientific community, the plastics industry maintains that exposure to chemically-active microplastics does not necessarily present a health risk. The United States Food and Drug Administration (FDA) argues that the amount of chemicals that are released from plastic products is not significant enough to cause health problems, despite the scientific consensus that ingesting minuscule doses of chemicals such as BPA can potentially accumulate, presenting a significant risk.[21] In response to growing consumer concerns, many plastic manufacturers have made their products BPA-free by replacing this chemical with other structurally similar chemicals such as Bisphenol-S, but alternative chemicals are not necessarily safer than BPA given that they tend to exhibit very similar properties.[22]

Avoiding microplastic and chemical exposure

Globally, around 8.4 million metric tonnes of phthalates and other plasticizers are consumed every year.[23] Taken together; the above sections confirm that the home environment is a potential driver of exposure to harmful chemicals through plastics. Though this research still remains in early stages of uncovering the actual risks of microplastics to human health, it is safe to assume that ingesting and inhaling such large numbers of microplastics is not good for our health given the toxins and pathogens that can be found on these particles.

As scientists work to provide evidence on the impacts of microplastics, new areas of concern continue to emerge. However, as long as the potential health risks of microplastics are still unknown, there will continue to be a lack of regulatory oversight over the plastics industry. With this in mind, it is up to individuals to take the necessary action to avoid this kind of exposure in favour of their health.

Avoiding plastic products can be beneficial not only for humans but also for the environment. This section covers some tips to avoid the problem of microplastics in the home.

- Use a glass kettle instead of a plastic kettle.
- Rinse baby bottles with cool sterile water following sterilization to wash away any microplastics that may have been released. If possible, substitute plastic baby bottles with glass ones.
- Drink tap water, filtered water, or water in steel bottles instead of plastic bottles.
- Use traditional tea bags or tea infusers instead of PET-made silky tea bags.
- Avoid plastics with recycling codes 3 (phthalates), 6 (styrene), and 7 (bisphenols).
- Store food and drinks in glass containers rather than plastic ones.
- If sticking with plastic bottles and containers, avoid putting them in the microwave and hand-wash them rather than putting them in the dishwasher, as the high temperatures can produce wear and tear that helps break down the plastic polymers.
- Use beeswax or reusable wax paper instead of plastic wrap.
- When looking for alternatives to takeout containers, choose brown or white paper boxes composed of 100% recycled paperboard, which have a seal to indicate they are compostable.
- Purchase fresh fruits and vegetables free of plastic packaging, or stock up on produce at a local farmer's market to reduce your produce's carbon footprint.
- Avoid certain home furniture depending on the materials and substances they are made of and clean your house often to avoid the accumulation of microplastics on different surfaces - use a damp microfiber cloth for dusting and vacuum frequently.
- Reduce the amount of new plastic toys gifted to children to avoid increased exposure to the chemicals found in these toys.

Through the above actions, individuals can begin to manage their exposure to microplastics in the home while making a positive contribution to our planet. The next step is recognizing our individual contributions to the plastic problem and taking a stance against the world's exorbitant production of plastic. Reducing waste, reusing products, and recycling discarded materials is the perfect way to approach waste management. These strategies and other actions

against the current excessive level of plastic demand across the world will be explored in subsequent segments of this series titled Plastics: Problems and Solutions.

References

1 Moore, Charles. "*Plastic pollution*". *Encyclopedia Britannica*, 15 Oct. 2020, www.britannica.com/ science/plastic-pollution

2 Tiseo, Ian. "*Global Plastic Production* 1950-2019 (*in Million Metric Tons*)*". 27 Jan. 2021, www.statista.com/statistics/282732/global-production-of-plastics-since-1950/

3 OECD. "*Improving Plastics Management: Trends, Policy Responses, and the Role of International Cooperation and Trade*". Policy Perspectives. OECD Environment Policy Paper No. 12. 2018. www.oecd.org/environment/waste/policy-highlights-improving-plastics-management.pdf

4 Li, D., Shi, Y., Yang, L. *et al.* "*Microplastic release from the degradation of polypropylene feeding bottles during infant formula preparation*". Nature Food 1, 746–754 (2020). https://doi.org/ 10.1038/s43016-020-00171-y

5 Tyree, Chris, and Dan Morrison. "*Plus Plastic: Microplastics Found in Global Bottled Water*". Investigative Report. 2018. https://orbmedia.org/stories/plus-plastic/

6 Westerhoff, Paul et al. "*Antimony Leaching from Polyethylene Terephthalate (PET) Plastic Used for Bottled Drinking Water*". ScienceDirect. Water Research. Volume 42, Issue 3, Pages 551-556, Feb. 2008. www.sciencedirect.com/science/article/abs/pii/S0043135407005246?via%3Dihub#!

Fan, Ying-Ying et al. "*Effects of storage temperature and duration on release of antimony and bisphenol A from polyethylene terephthalate drinking water bottles of China*". Environmental pollution (Barking, Essex : 1987) vol. 192 (2014): 113-20. doi:10.1016/j.envpol.2014.05.012

Chapa-Martínez, C.A. et al. "*An evaluation of the migration of antimony from polyethylene terephthalate (PET) plastic used for bottled drinking water*". ScienceDirect. Science of The Total Environment. Volume 565, Pages 511-518. September 2016. www.sciencedirect.com/science/ article/abs/pii/S0048969716308865

7 Laura M. Hernandez et al. "*Plastic teabags release billions of microparticles and nanoparticles into tea*". Environmental Science & Technology 2019 53 (21), 12300-12310. DOI: 10.1021/ acs.est.9b02540. https://pubs.acs.org/doi/abs/10.1021/acs.est.9b02540

8 Marketplace, Megan Griffith-Greene. "*Pesticide Traces in Some Tea Exceed Allowable Limits*". CBC News. CBC/Radio Canada, 08 Mar. 2014. www.cbc.ca/news/canada/pesticide-traces-in-some-tea-exceed-allowable-limits-1.2564624

9 Gibbens, Sarah. "*The Sticky Problem of Plastic Wrap*". Environment: The story of Plastic. National Geographic,12 July 2019. https://www.nationalgeographic.com/environment/2019/07/ story-of-plastic-sticky-problem-of-plastic-wrap/

10 Fox, Eleanor Goldberg. "*Food Packaging Is Full of Toxic Chemicals – Here's How It Could Affect Your Health*". The Guardian. Guardian News and Media, 28 May 2019. https:// www.theguardian.com/us-news/2019/may/28/plastics-toxic-america-chemicals-packaging

11 Viswanathan, Radhika, and Julia Belluz. *"The Problem with All the Plastic That's Leaching into Your Food*." Vox, Voxmedia, 11 Sept. 2018, www.vox.com/science-and-health/ 2018/9/11/17614540/plastic-food-containers-contamination-health-risks

12 Shu, Huan, et al. "PVC Flooring at Home and Uptake of Phthalates in Pregnant Women." *Wiley Online Library*, John Wiley & Sons, Ltd, 10 Nov. 2018, onlinelibrary.wiley.com/doi/full/10.1111/ ina.12508

13 Ragusa, Antonio, et al. *Plasticenta: First Evidence of Microplastics in Human Placenta*. 2 Dec. 2020, www.sciencedirect.com/science/article/pii/S0160412020322297

14 Aurisano, Nicolò, et al. *"Chemicals of Concern in Plastic Toys."* Environment International, Pergamon, Volume 146, January 2021, 106194. ScienceDirect. https://doi.org/10.1016/ j.envint.2020.106194

15 Talsness, Chris E et al. *"Components of plastic: experimental studies in animals and relevance for human health."* Philosophical transactions of the Royal Society of London. Series B, Biological sciences vol. 364,1526 (2009): 2079-96. doi:10.1098/rstb.2008.0281

16 Ejaredar, Maede et al. *"Phthalate exposure and childrens neurodevelopment: A systematic review."* Environmental research vol. 142 (2015): 51-60. doi:10.1016/j.envres.2015.06.014

17 LaMotte, Sandee. *"Chemicals in Plastics Damage Babies' Brains and Must Be Banned, Expert Group Says."* CNN, Cable News Network, 20 Feb. 2021, www.cnn.com/2021/02/20/health/baby-brain-damage-plastic-phthalates-wellness/index.html?utm_medium=social&utm_source=twCNN&utm_content=2021-02-20T18%3A45%3A09&utm_ter m=link

18 Hagai Levine, Niels Jørgensen, Anderson Martino-Andrade, Jaime Mendiola, Dan Weksler-Derri, Irina Mindlis, Rachel Pinotti, Shanna H Swan, *"Temporal trends in sperm count: a*

systematic review and meta-regression analysis", Human Reproduction Update, Volume 23, Issue 6, November-December 2017, Pages 646–659, https://doi.org/10.1093/humupd/dmx022

19 Hunt, Patricia A. et al. *"Bisphenol A alters early oogenesis and follicle formation in the fetal ovary of the rhesus monkey"*. Proceedings of the National Academy of Science of the United States of America. PNAS Early Edition. vol. 109 (aug, 2012), issue 43, pages 17525-17530. www.pnas.org/cgi/doi/10.1073/pnas.1207854109

20 Wang, Zhe et al. *"Low-Dose Bisphenol A Exposure: A Seemingly Instigating Carcinogenic Effect on Breast Cancer."* Advanced science (Weinheim, Baden-Wurttemberg, Germany) vol. 4,2 1600248. 21 Nov. 2016, doi:10.1002/advs.201600248

21 Center for Food Safety and Applied Nutrition. *"Bisphenol A (BPA)."* U.S. Food and Drug Administration, FDA, 27 June 2018, www.fda.gov/food/food-additives-petitions/bisphenol-bpa

22 Gibbens, Sarah. *"Exposed to Extreme Heat, Plastic Bottles May Ultimately Become Unsafe."* Environment. National Geographic, 19 July 2019, www.nationalgeographic.com/environment/ 2019/07/exposed-to-extreme-heat-plastic-bottles-may-become-unsafe-over-time/

23 *"Plasticisers Fact Sheet*", European Plasticisers. Infinite opportunities. Cefic Aisbl, March 2020, www.plasticisers.org/wp-content/uploads/2019/08/Plasticisers_Factsheet_EN_MAY2020.pdf