Plastic and Human Health:
An urgent case for reducing plastic production

Introduction

From extraction of feedstock (e.g., oil, gas, and coal) to disposal, plastic threatens the health of people and wildlife, exacerbating the climate and biodiversity crises. Human exposure to related pollutants is an unavoidable effect of plastic production and use, through direct contact, harmful emissions, and pervasive nanoplastics. Micro- and nanoplastic particles are now commonly found in the air[1] as well as in water, snow, ice, and soil across most if not all types of ecosystems.[2] Increasingly, they are also being found in all systems of the human body, including in breast milk and placentas.[3] Meanwhile, the chemicals in plastic have been linked to death, illness, and disability.

Scientists have known since the 1950s that chemicals in plastic packaging and containers can enter our bodies through the food and beverages we consume. Today, the scientific understanding that plastic is harmful to human health is well documented; health scientists all over the world across diverse disciplines of study are warning about the dangers of plastic. However, without government action and corporate accountability, we will not be able to rid our homes of toxic plastics. Companies and governments must put our health ahead of profits and end the age of plastic.

Over the past 20 years, the number of peer-reviewed articles that have been published on the health impacts of plastics has grown by least 900%,[4] and it has become crystal clear that it is a serious human health concern that must be urgently addressed. While there will always be more to learn, the overwhelming evidence that plastic is causing harm requires a much more precautionary approach and immediate action to reduce our exposure.

Without dramatically reducing plastic production, it will be impossible to end plastic pollution or to eliminate the health threats from microplastics and plastic chemicals. The Global Plastics Treaty[5] must cut plastic production by at least 75% by 2040.

Production harms

Numerous studies have documented the impacts of pollution from petrochemical and plastic production facilities on the health of people living near and working in these facilities.[6] It is clear that from the beginning to the end of the plastics lifecycle, human lives are threatened:

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[1] Revell, L.E., Kuma, P., Le Ru, E.C., Somerville, W.R.C., & Gaw, S. (2021). Direct radiative effects of airborne microplastics. *Nature*, *598*, 462–467. https://doi.org/10.1038/s41586-021-03864-x

[2] Wang, Z., Saadé, N.K., & Ariya, P.A. (2021). Advances in ultra-trace analytical capability for micro/nanoplastics and water-soluble polymers in the environment: Fresh falling urban snow. *Environmental Pollution*, *276*, 116698. https://doi.org/10.1016/j.envpol.2021.116698

[3] See e.g. Liu, S., et al. (2023). Detection of various microplastics in placentas, meconium, infant feces, breastmilk and infant formula: A pilot prospective study. The Science of the Total Environment, 854, 158699. https://doi.org/10.1016/j.scitotenv.2022.158699

[4] Minderoo Foundation. (n.d.). Plastic health map, 2002–2022. https://r.flo.minderoo.org/Systematic-Evidence-Map/

[5] UN Environment Programme, Intergovernmental Negotiating Committee on Plastic Pollution (Online). https://www.unep.org/inc-plastic-pollution

[6] See e.g. Landrigan, P.J., et al. (2023). The Minderoo-Monaco Commission on Plastics and Human Health. *Annals of Global Health*, *89(1)*, 23. https://doi.org/10.5334/aogh.4056

- Workers in the plastic industry and communities near plastic-making facilities are exposed to toxic chemicals from the plastics they collect, sort, and dismantle for recycling, which pose risks of life-long health conditions, including cancer, lung disease, and infertility.
- Residents of "fenceline" communities near plastic factories experience higher rates of health issues, including premature birth, low birth weight, childhood cancers, heart and lung problems, mental health conditions, and an increased risk of car accidents.
- The adverse effects of plastics disproportionately impact the world's poorest and most vulnerable populations.[7]

Problematic plastic polymers and chemicals

The longer it takes us to reduce production and eliminate the dangers of plastic, the worse the harms to human health will become. Plastics contain over 13,000 chemicals, many of which remain untested and may be toxic to human health. More than 3,200 identified chemicals found in plastics have been associated with severe health concerns, including infertility, nervous system disorders, and hormonal imbalances. These chemicals have been implicated in the development of diseases such as cancer, diabetes, heart conditions, and obesity.[8] Regulations requiring transparency on the use of chemicals, even in food and beverage packaging, are essentially nonexistent.

The following are some of the main groups of chemicals of concern contained in the plastic products many of us interact with daily.

Phthalates

- Phthalates are a group of chemicals used to make plastic packaging more flexible and durable. They have been termed the "everywhere chemicals" because of their prevalence in numerous types of food, personal care, and household products.
- Most people are exposed to phthalates through food and beverage packaging. They have been found in common household goods such as bottled water, dairy products, oils, and other foods.[9]
- Phthalates are known endocrine disruptors, meaning they can interfere with normal hormone function, leading to a range of negative health impacts including problems with sperm quality and fertility, premature birth rates, endometriosis, early puberty, neurological disorders, altered immune function, certain cancers, respiratory problems, metabolic issues, diabetes, obesity, heart problems, learning disabilities, and more.[10]

[7] Ibid.
[8] UN Environment Programme. (2023). Chemicals in plastics: A technical report. https://www.unep.org/resources/report/chemicals-plastics-technical-report
[9] Giuliani, A., Zuccarini, M., Cichelli, A., Khan, H., & Reale, M. (2020). Critical review on the presence of phthalates in food and evidence of their biological impact. *International Journal of Environmental Research and Public Health*, *17(16)*: 5655. https://doi.org/10.3390%2Fijerph17165655
[10] Ibid.

Forever chemicals (PFAS)

- Per- and polyfluoroalkyl substances (PFAS) are a group of chemicals used in a wide variety of everyday products, including food packaging, non-stick cookware, clothing, and cosmetics, due to their ability to repel water and other substances.
- PFAS are known as “forever chemicals” because they are highly persistent and toxic. Like phthalates, they are endocrine disruptors, with a similar set of potential health impacts; these long-lasting chemicals accumulate in the environment, and they are now widely present in drinking water.[11]
- Newer types of PFAS are also building up inside people’s bodies. Studies have found PFAS in the blood of as many as 99% of people tested,[12] and one study found PFAS in 100% of breast milk samples that were tested.[13]
- The persistence and toxicity of PFAS require that they be regulated as a class rather than as individual chemicals.

Bisphenols

- Bisphenols, including the well-known bisphenol A (BPA), are a group of chemicals used in industrial processes for various purposes such as flame retardancy, UV stabilization, and thermal paper development.
- Toxicology studies have identified bisphenols as endocrine disruptors, although the exact mechanisms of their impact on health are not fully understood. They are considered estrogenic, mimicking the action of female hormones.[14]
- Exposure to bisphenols, as seen in laboratory studies, has been associated with a range of significant health impacts, including cancer, reproductive system disturbances, neurological effects, mammary gland disruptions, metabolic changes, and obesity.[15]
- Manufacturers sometimes substitute BPA with other bisphenols like BPF or BPAF in food packaging, but indications that these alternatives may also have health risks[16] points to the need to regulate bisphenols as a class rather than as individual chemicals.

Polyvinyl chloride (PVC)

- Polyvinyl chloride (PVC) is manufactured from vinyl chloride monomer and is primarily utilized in the production of plastic materials.
- The International Agency for Research on Cancer (IARC) and the US Environmental Protection Agency (EPA) classify vinyl chloride as carcinogenic to

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[11] Wee, S.Y., and Aris, A.Z. (2023). Revisiting the “forever chemicals”, PFOA and PFOS exposure in drinking water. *npj Clean Water*, *6*, 57. https://doi.org/10.1038/s41545-023-00274-6

[12] Yu, C.H., Riker, D., Lu, S.-e., and Fan, Z. (2020). Biomonitoring of emerging contaminants, perfluoroalkyl and polyfluoroalkyl substances (PFAS), in New Jersey adults in 2016–2018. International *Journal of Hygiene and Environmental Health*, *223(1)*, 34–44. https://doi.org/10.1016/j.ijheh.2019.10.008

[13] Zheng, G., Schreder, E., Dempsey, J.C., Uding, N., Chu, V., Andres, G., Sathyanarayana, S., and Salamova, A. (2021). Per- and polyfluoroalkyl substances (PFAS) in breast milk: Concerning trends for current-use PFAS. Environmental Science & Technology, 55(11), 7510–7520. https://doi.org/10.1021/acs.est.0c06978

[14] See e.g. Pelch, K., et al. (2019). A scoping review of the health and toxicological activity of bisphenol A (BPA) structural analogues and functional alternatives. *Toxicology*, *424*, 152235. https://doi.org/10.1016/j.tox.2019.06.006

[15] Ibid.

[16] Ibid.

humans. When PVC is used in food packaging, there is a risk that any unreacted monomer could migrate from the packaging to the food.[17]

Benzotriazoles

- Benzotriazoles are chemicals commonly used to help plastics withstand UV rays from the sun. They are often found in plastic bottle caps, food packaging, and shopping bags. Benzotriazoles stick to fats, build up in living things, and don't break down easily in the environment. Studies have found them in breast milk[18] and in blood and urine after exposure.[19]
- Endocrine-disrupting effects, hepatotoxicity and neurotoxicity, and the risk of promoting the development of endometrial carcinoma are all cause for grave concern.[20]

End of life: Recycling, landfills, and incineration
It is important to understand that people are not only exposed to toxic chemicals by the production and use of virgin plastic, but also by plastic recycling throughout the recycling stream:[21]

- When plastics are exported under the guise of recycling, they are often dumped or burned, leading to environmental and food chain contamination.
- Workers and their communities are exposed to toxic chemicals from plastics they collect, sort, and dismantle for recycling. Plastic recycling areas should be regulated in the same ways as facilities that handle hazardous waste and contaminated sites that release hazardous chemicals.
- Recycled plastic products expose consumers to toxic chemicals, including chemicals that have been globally banned. Recycling can combine toxic chemicals from different plastics and create new hazardous chemicals, all of which end up in recycled plastic products.

All forms of plastic disposal are problematic:

- Mechanically recycled plastic materials often contain harmful chemicals, which can come from various sources. Most plastics are made from fossil carbon (oil, gas, and coal) mixed with toxic chemicals. When the original plastic products are recycled, these chemicals transfer directly into the recycled plastic. In addition, harmful substances can enter recycled plastics through contamination in the plastic waste stream and during the recycling process itself.

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[17] Muzeza, C., Ngole-Jeme, V., and Msagati, T.A.M. (2023). The mechanisms of plastic food-packaging monomers' migration into food matrix and the implications on human health. *Foods*, *12(18)*, 3364. https://doi.org/10.3390/foods12183364
[18] Kim, J-W., et al. (2019). Occurrence of benzotriazole ultraviolet stabilizers (BUVSs) in human breast milk from three Asian countries. *The Science of the Total Environment*, *655*, 1081–1088. https://doi.org/10.1016/j.scitotenv.2018.11.298
[19] Fischer, C., Leibold, E., Hiller, J., and Göen, T. (2023). Human metabolism and excretion kinetics of benzotriazole UV stabilizer UV-327 after single oral administration. *Archives of Toxicology*, *97(1)*, 165–176. https://doi.org/10.1007%2Fs00204-022-03401-3
[20] Shi, Z.-Q., Liu, Y.-S., Xiong, Q., Cai, W.-W., & Ying, G.-G. (2019). Occurrence, toxicity and transformation of six typical benzotriazoles in the environment: A review. *The Science of the Total Environment*, *661*, 407–421. https://doi.org/10.1016/j.scitotenv.2019.01.138
[21] Greenpeace USA. (2023). Forever toxic: The science on health threats from plastic recycling. https://www.greenpeace.org/usa/reports/forever-toxic/

- Chemical or advanced recycling is a blanket term used to describe various plastic-to-fuel and plastic-to-plastic technologies, such as pyrolysis, depolymerization, and solvolysis. These processes are promoted as means to turn plastic waste into new plastic resin, but they have yet to be proven viable at scale from an economic or environmental standpoint. Plastic-to-fuel facilities are both waste and petrochemical factories, producing toxic emissions as well as liquid effluent, and solid waste. The plastic-derived fuel releases further toxic substances when burned. There have been several high-profile failures in these types of facilities, including fires and explosions, and the technology itself is expensive and energy inefficient.[22]
- Plastics in landfills break down into tiny airborne toxic particles that contaminate the soil and waterways and enter the food chain when animals accidentally ingest them. Toxic leachate from landfills can also contaminate groundwater.
- Burning plastic impacts air quality and respiratory health, as it can release the chemicals from the plastics (including bisphenols and phthalates) into the air. Plastic incineration can also lead to the formation of extremely dangerous chemicals such as dioxins.

Conclusion: Call to Action

Global plastic production is set to triple by 2060.[23] Putting more and more untested and dangerous chemicals into the world while knowing that doing so is causing illness and death is unconscionable. The health impacts of hazardous chemicals in plastics are estimated to have cost the US healthcare system alone over $249 billion in 2018.[24] We cannot afford to continue absorbing these costs or suffering the negative health impacts in order to prop up big oil and big plastic. The time to protect our health from toxic and harmful plastics is now. More research is not needed to tell us what we already know: plastics are not safe for human health. World leaders have an opportunity with the Global Plastics Treaty to limit the impacts on our health and protect the environment. An effective Global Plastics Treaty must not only cut plastic production by at least 75% by 2040 but also eliminate problematic polymers, dangerous chemicals, and single-use plastics.

[22] GAIA. (2019). Questions and answers: Chemical recycling. https://www.no-burn.org/wp-content/uploads/Questions-and-Answers_Chemical-Recycling.pdf

[23] OECD. (2022). Global plastic waste set to almost triple by 2060, says OECD. https://www.oecd.org/environment/global-plastic-waste-set-to-almost-triple-by-2060.htm

[24] Trasande, L., Krithivasan, R., Park, K., Obsekov, V., & Belliveau, M. (2024). Chemicals used in plastic materials: An estimate of the attributable disease burden and costs in the United States. *Journal of the Endocrine Society*, *8(2)*, bvad163. https://doi.org/10.1210/jendso/bvae019